THE

BOOK of NATURE;

OR, THE

HISTORY OF INSECTS:

Reduced to diſtinct CLASSES, confirmed by particular INSTANCES, Diſplayed in the Anatomical Analyſis of many SPECIES,

AND

ILLUSTRATED with COPPER-PLATES,

INCLUDING

The Generation of the FROG, the Hiſtory of the EPHEMERUS, the Changes of FLIES, BUTTERFLIES, and BEETLES;

WITH THE

Orginal Diſcovery of the MILK-VESSELS of the CUTTLE-FISH, and many other curious Particulars.

By JOHN SWAMMERDAM, M. D.

WITH

The LIFE of the AUTHOR, by HERMAN BOERHAAVE, M. D.

Tranſlated from the DUTCH and LATIN Original Edition,

By THOMAS FLLOYD.

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By JOHN HILL, M. D.

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MDCCLVIII.

TO THE RIGHT HONOURABLE

GEORGE

EARL OF MACCLESFIELD,

PRESIDENT

OF THE ROYAL SOCIETY,

This WORK

Is moſt Humbly Inſcribed,

By His LORDSHIP'S

Moſt Devoted Humble Servant,

The EDITOR.

THE

LIFE

OF

JOHN SWAMMERDAM.

JAMES Theodorus was born in Swammerdamme, a village of Holland ſituated upon the Rhine, between Leyden and Woerden; and removing afterwards to Amſterdam, where he carried on the timber trade, obtained the ſurname of Swammerdam from the place of his nativity. In this laſt place heaven bleſſed him on the laſt day of January in the year MDCVI, with a ſon, who was called John James Swammerdam, who followed in that famous city the buſineſs of an apothecary. As this John was very ſtudious of natural hiſtory, and very well ſkilled in ſeveral branches of it, ſo he diligently improved every opportunity of cultivating it, which his reſidence and way of life afforded; and for fifty years together ſpared neither pains or expence in procuring proper materials for that purpoſe. And indeed his collection was very magnificent, his houſe being full of animals, inſects eſpecially, vegetables, and foſſils, though without the leaſt confuſion, every thing being diſpoſed in its proper place and order. But the chief ornaments of his muſeum were curioſities from both the Indies, and particularly the porcelain of China and Japan. Both citizens and ſtrangers viewed this collection with admiration; and the greateſt princes, that paſſed through Amſterdam, viſited it, as one of the things beſt worth their attention in that famous city. Many of theſe, delighted with the ſight of ſo beautiful a ſpectacle, offered to purchaſe it, but were ſurpriſed at the price, the poſſeſſor valuing it at ſixty thouſand Dutch florins; though after his death, when his curioſities were ſold publickly in ſingle lots, they ſcarce fetched one ſixth of that price.

This great naturaliſt, and Barentje Corver, daughter of John Janſz Corver, were the parents of John Swammerdam, who was born at Amſterdam the twelfth of February MDCXXXVII, and lived to be the celebrated author of this valuable work.

His father intended him for the church, and with this view took care to procure him early inſtructions in Latin and Greek; but our author, after a ſerious examination of his own diſpoſition and talents, thought himſelf unequal to ſo important a taſk, and brought his father to change his former intention, who thereupon conſented to his ſon's applying himſelf to phyſic; but as he kept him at home till he ſhould be properly qualified to engage in that ſtudy, he frequently employed him in cleaning his curioſities, and putting every thing in its proper place. This occupation inſpired our author in a manner from his childhood, with a tafte for natural hiftory, fo that not content with the furvey of thofe curiofities that his father had purchafed, he foon began to make a collection of his own by catching fome, and buying or bartering for others, all which he difpofed in certain claffes; and compared with the accounts given of them by the beft writers. However, when grown up, he very ferioufly attended to his anatomical and medical ftudies, but all the while with a mind bent on attempts of the greateft importance. Accordingly he fpent both day and night in difcovering, catching, and examining, the flying infects proper to thofe two different times, not only in the province of Holland, but in that of Gueldres, and in the the province of Utrecht. He ranfacked with this view the air, the land, and the water; fields, meadows, paftures, corn grounds, downs, waftes, fand hills; rivers, ponds, wells, lakes, feas, and their fhores and banks; trees, plants, ruins, caves, uninhabited places, and even bog-houfes, in fearch of Eggs, Worms, Nymphs, and Butterflies; in order to make himfelf acquainted with the nefts of infects, their food, manner of living, diforders, changes or mutations, and their feveral ways or methods of propagation; and, indeed, while yet a very young man, he had made more difcoveries in regard to all thefe particulars, and obtained more certainty, than the known authors of all the preceding ages put together. This, however incredible it may appear to fome, is notwithftanding matter of fact. Perfons properly qualified to judge of his fuccefs, have honoured it with the fame teftimony.

Our author, thus initiated in natural hiftory, came to Leyden in the year MDCLI, to purfue his ftudies in the Dutch univerfity, of which he was admitted a member the eleventh of October, and attended affiduoufly for two years together the lectures in furgery of the celebrated John Van Horne, and thofe in phyfic of Francis Sylvius de la Boe; and his progrefs in thofe noble ftudies was fo anfwerable to his diligence, that on the eleventh of October MDCLXIII, he was admitted a candidate of phyfic in that famous univerfity, after undergoing the examinations prefcribed on that occafion. Our author, on his arrival at Leyden, contracted a friendfhip with that great anatomift Nicholas Steno, and ever after lived with him in the greateft intimacy. He likewife commenced a friendfhip with Rynier de Graaf, another eminent anatomift; but emulation, or rather envy, afterwards changed it to an inveterate hatred. The curiofities of anatomy now began to make a confiderable impreffion on our author, formed it feems by nature herfelf for the cultivation and improvement of that noble fcience; fo that having gone through his courfes with the moft fudden and unexpected fuccefs, he immediately began to confider how the parts of the body prepared by diffection, could be preferved and kept in conftant order and readinefs for anatomical demonftrations; as fuch a difcovery would free him not only from the trouble of repeated diffections, but likewife from the difficulty of obtaining frefh fubjects, and the difagreeable neceffity of infpecting fuch as were already putrefied. And herein he fucceeded, as he had done before, in his nice contrivances to diffect and otherwife manage the minuteft infects. Sylvius, the moft diligent anatomift of his time, made good ufe of this our author's great art and indefatigable induftry; but was chiefly delighted at his extraordinary fkill in diffecting Frogs; for Swammerdam had demonftrated to him by actual experiment, fo early as the fifteenth of January of this year, that in this animal the air at the time of infpiration could be derived to the artery and pulmonary vein, and thence to both regions of the heart. See Sylv. Difp. Med. VII. §. LXXIX. — LXXXVIII.

After

After this our author made a journey into France, where he ſpent ſome time at Saumur, in the houſe of Tanaquil Faber, and made a variety of obſervations upon inſects. It was there, that on the nineteenth of June MDCLXIV, he diſcovered, by means of very ſlender tubes, the valves of the lymphatic veſſels, which he immediately ſent, on the twenty-eighth, delineated with his own hand, to his friend Steno, who he then thought reſided at Copenhagen. See his treatiſe on Reſpiration, page 90, 91. He afterwards wrote to Thevenot on the twenty-fourth of September in the year following, that perhaps the famous Frederick Ruyſh might have ſeen thoſe paintings before he publiſhed his own on the ſame ſubject: this he mentioned to Thevenot, on occaſion of his ſending him from Paris to Amſterdam, the little treatiſe on thoſe valves which Ruyſh publiſhed the ſame year at the Hague. But Swammerdam barely hinted this, without directly charging Ruyſh with plagiariſm, which he owns it is impoſſible for him to prove; on the contrary, he expreſſes a great deal of affection for his rival in this diſcovery, and ſays, he is ſincerely rejoiced at his having the honour of it. And no doubt Swammerdam did no more than juſtice to Ruyſh's merit on this occaſion, as this laſt, long before the edition of his book, had ſhewed theſe valves to others, and even to Bils. But the letters directed to Steno at Copenhagen, could not reach his hands in Holland, where he then reſided, but very late; and if Ruyſh had ſeen them, how could he have had the aſſurance to publiſh the drawings taken notice of, without mentioning Swammerdam, who was then living, and even on the ſpot. Among other things, our author, during his ſtay in the neighbourhood of the Loire, obſerved and deſcribed the flying inſect called Libella or Dragon Fly, and likewiſe ſome Hemerobia or Day Flies. From Saumur he went to Paris, where he lived in the ſame houſe, and in the greateſt friendſhip with Steno. He likewiſe contracted an intimacy with Melchiſedec Thevenot, a very worthy gentleman, and formerly the French king's miniſter at Genoa, who moſt hoſpitably received and entertained him and Steno at his pleaſant country ſeat of Yſſi, at a few miles diſtance from Paris, and thereby afforded our author an opportunity of making further obſervations upon the inſect creation. Not ſatisfied with this piece of politeneſs, he in conſideration of Swammerdam's ſingular abilities, and the great pains he had taken to cultivate them, made him a moſt liberal offer of every thing he thought requiſite to promote his ſtudies. Our author ever retained a grateful memory of thoſe favours, and others which he afterwards from time to time conſtantly received from this great reſpecter of merit; and a little before his death owns in one of his letters, that he had never found in any other perſon, ſo true, faithful, and ſure a friend. Thevenot introduced his gueſt to a great many other gentlemen, who met frequently at his houſe with a view of cultivating the arts and ſciences; but in all their aſſemblies our author continued for a long time, notwithſtanding all the company's entreaties, a ſilent auditor only, till his modeſty being at laſt overcome by repeated importunities, he found himſelf obliged to give one and then another ſpecimen of his manner of diſſecting inſects, and of ſhewing their inward parts; by which he gained great applauſe, as by his tacit ſkill he effectually ſilenced the talkative ignorance of others. Thevenot, moreover, ſtrenuouſly recommended our author's ſkill to that great man Conrad Van Beuningen, a ſenator and burgomaſter of Amſterdam, and at that time that republick's miniſter at the court of France; who obtained leave for Swammerdam at his return home, to diſſect the bodies of ſuch patients as ſhould happen to die in the hoſpital of that city: and our author improved himſelf himfelf greatly in anatomy, by making the proper ufe of fo favourable an opportunity.

But this was not the only opportunity which providence threw in our author's way at this time, as the principal phyficians of Amfterdam had formed a college, and had agreed to meet together every other week in order to confer on medical, but chiefly anatomical fubjects, and to make experiments relative thereto. The obfervations of this fociety of learned men were afterwards publifhed by Cafper Commelin, in the year MDCLXVI and LXVII, before Swammerdam had been created doctor of phyfic; notwithftanding which, he was the firft to furnifh materials for it. It was he, and he alone, that made in the faid college, with his own hand, a drawing of the fpinal marrow, publifhed by Blafius at the fame place; and on this occafion he wrote to Thevenot the following particulars. I. That the fpinal marrow confifts entirely of fibres. II. That thofe diftinct fibres meet and terminate in fome part of the brain. III. That there iffue fibrous nerves from the fibres of the fpinal marrow. IV. That the pia mater is altogether extended into hollow fheaths. V. That all thefe things may be eafily feen, by fuddenly placing the yet warm fpinal marrow along with the vertebræ containing it, in cold water, and breaking the vertebræ with great caution from the marrow, after having fuffered both to remain in that fituation during the fpace of a day and a night. This letter was written the firft of April MDCLXVI; our author at the fame time tried many experiments by injecting the veffels of living animals with various liquids. See de Refp. page 103 and 107. He even made fome chemical experiments on the cold fermentation produced by mixing together the falt of urine, and the fpirit of glauber falts, ibid. p. 111. He then too compofed that laborious effay on refpiration, which he was to maintain on his declaiming for his degrees in phyfic. We may be convinced by reading this performance, that he only purfued fuch things as he thought of in his own way, and of whofe truth he had fatisfied himfelf, and could convince others by experiments, without borrowing any affiftance from other writers. Having finifhed this differtation, he came back to Leyden to take out his degrees; and took occafion of his ftay there to cultivate a moft intimate friendfhip with the famous Van Horne, who had been formerly his preceptor in the ftudy of anatomy. With this gentleman he then practifed this ufeful art, and prepared a great many things in many various ways, while both publickly owned a community of fentiments and difcoveries. The profeffor moft liberally fupplied all kinds of materials, the other directed the work, and at the fame time made with his own hands the moft mafterly drawings of each difcovery, which he immediately forwarded with fuitable obfervations to Matthew Slade. Nothing here was wanting to carry on fo laudable an undertaking. Van Horne's liberality contributed the fubjects, the inftruments, and every other expence; and Swammerdam's wonderful fkill was day and night employed in making proper ufe of them. It was at this time, and on the twenty-fecond of January MDCLXVII, that in Van Horne's own houfe, Swammerdam firft injected the uterine veffels of a human fubject with a ceraceous matter, which moft ufeful attempt he afterwards improved and perfected. The twenty-fecond of February of the fame year, he was admitted to his degrees as doctor of phyfic, after having publickly maintained his diatriba or thefis on refpiration; which was then conceived but in fhort and contracted arguments, but appeared the March following with confiderable additions in a volume from the printing-houfe of Gafbekios, with a dedication to the illuftrious Thevenot, and adorned with a frontifpiece of a moft elegant figure

figure of the reciprocal copulation of the hermaphrodite houſe Snail. John Baptiſt Van Lamſweerde publiſhed in oppoſition to this of Swammerdam another moſt vehement diſſertation, which he entitled, "An Exſpiration of Swammerdam's Syſtem of Reſpiration;" but this attempt fell ſhort of its author's expectation: for though Swammerdam's book may contain ſome things out of the way, they will be readily excuſed by equitable judges, in conſideration of the many curious and juſt obſervations that are to be met with in every part of that work. Another occupation of Swammerdam's at this time was to blow up with air the parts of the body firſt properly evacuated and cleanſed, that by drying in this ſituation they might afterwards retain it, and ſo at all times afford an opportunity of obſerving and deſcribing them. This certainly muſt be allowed one of the moſt uſeful inventions in anatomy, as by it we can erect and ſtiffen parts, which would putrefy on lying one upon another, and which if injected with wax would be rendered obſcure and confuſed. It was thus our author cultivated anatomy with the greateſt art and labour, in conjunction with the celebrated Van Horne; but a quartan ague, which attacked him this year, brought him ſo very low, that he found himſelf under a neceſſity of diſcontinuing his anatomical ſtudies, which on his recovery he entirely neglected, in order to give himſelf up to the ſtudy of inſects. In the year MDCLXVIII the great duke of Tuſcany being then in Holland with Mr. Thevenot, in order to ſee the curioſities of the country, came to view thoſe of our author and his father, and ſurveyed them with the greateſt delight, and his uſual taſte and attention for natural hiſtory. On this occaſion Swammerdam made ſome anatomical diſſections of inſects in the preſence of that great prince, who was both a lover and a moſt ſkilful judge of ſuch things, and who was ſtruck with admiration at our author's great ſkill in managing them, eſpecially at his proving that the future Butterfly lay with all its parts neatly folded up, in a Caterpillar, by actually removing the integuments that covered the former, and extricating and diſtinctly exhibiting all its parts, however minute, with incredible ingenuity, and by means of inſtruments of an unconceivable fineneſs. On this occaſion his ſerene highneſs offered our author twelve thouſand florins for his ſhare of the collection, on condition of his removing them himſelf into Tuſcany, and coming to live at the court of Florence. In this certainly the prince acted very wiſely, as thoſe curioſities would be in the greateſt danger of being loſt or becoming uſeleſs, if not preſerved and ſhewn by the great genius that had collected them, and who was alone capable of ſhewing every article, and exhibiting them to the greateſt advantage; but Swammerdam, who hated a court life above all things, rejected his highneſs's propoſal. Beſides, he could not put up with the leaſt reſtraint in religious matters, either in point of ſpeech or practice. In the mean time, he had the happineſs of diſcovering in the diſſection of an overgrown Acipenſer, a very large pancreas, which, by diſcharging its fluid contents into the firſt inteſtine through a great many ſpacious and open-mouthed channels, gave a moſt ſatisfactory opportunity of examining this, at that time, ſo famous and much-talked-of fluid, in which, on the ſtricteſt examination, he could diſcover no acid taſte, but rather a bitteriſh rankneſs, reſembling that of gaurus, or pickle made of fiſh.

This our author affirmed publickly, contrary to what had been before advanced by de Graaf and Sylvius. He alſo made ſome obſervations in the hoſpital, but merely as ſupplementary additions to his other inquiries; for he now made the nature and properties of inſects his chief ſtudy, and purſued it with infinite diligence, and without the leaſt relaxation; ſo that in the year MDCLXIX, he publiſhed a general hiſtory of them, a work equally remarkable for the author's great boldneſs in the attempt, and happy ſucceſs in the execution. This performance he dedicated to the honourable the burgomaſters of Amſterdam. But as he was entirely bent on perfecting this work, and collecting of inſects from every quarter of the world, and then diſpoſing them in ſeparate boxes in order to form a compleat catalogue, which was attended with great and conſtant expences, without the leaſt return. Our author's father, who had always kept him at home, and ſupplied all his expences, began to take offence at his proceedings; for though he was now above thirty years old, and conſequently had ſpent the beſt years of his life, he had not as yet engaged in any buſineſs that could ſerve to render him eaſy and independant. His father on this account omitted no opportunity of reproving his ſon for this his thoughtleſs way of acting, which he would have had him change for the practice of phyſic; but inſtead of prevailing on him by his remonſtrances, they only ſerved to make him redouble his endeavours according to his diſpoſition, that he might the ſooner finiſh the great taſk in which he had ſo couragiouſly, though perhaps unadviſedly, engaged; all the while ſtriving to divert his father's anger, by promiſing him, that as ſoon as he had completed his undertaking, he would in good earneſt apply himſelf to the practice of phyſic. But his father ſeeing no probability of his ſon's accompliſhing his purpoſe, nor yet of being able to divert him from it by fair means, threatened him ſeverely that if he did not immediately exert his talents as a phyſician, but obſtinately perſiſted in his anatomical ſtudies, his expenſive reſearches after inſects, and his experiments of that kind, he would neither ſupply him with money or cloaths; and to ſhew he was in earneſt, he immediately deprived him of the means of purſuing what he had begun. Our author therefore, though exhauſted with continual labours, and moreover afflicted with a continual bad ſtate of health, at laſt conſented to take his father's advice, the juſtneſs of which he now began to perceive; but his bad health rendered him quite unfit to bear the fatigues uſually attending the practice of phyſic, ſo that he thought it was proper that he ſhould retire into the country for ſome time, in order to recover his ſtrength, and with a view of returning to his buſineſs with new force and ſpirits. But he was ſcarce ſettled in his country retirement, when in the month of June MDCLXX, he relapſed into his former occupation, the torrent of his genius that way being ſo much favoured by the ſolitarineſs of the place, and the favourable opportunity of examining inſects in their very haunts and ſcenes of propagation. Thevenot, in the mean time, informed by his correſpondents in Holland of the diſagreement between our author and his father, and the bad conſequences that might probably attend it, did all that lay in his power to engage the former to retire into France, where he moſt generouſly offered to provide him with every thing requiſite for the purſuit of his favourite ſtudies. But whatever impreſſion this propoſal might have made on the ſon, the father forbid him to accept of it, as appears by a letter of his to Mr. Thevenot, dated the thirtieth of October of the ſame year. The ſon upon this, to oblige and appeaſe his incenſed father, made an accurate ſurvey of every curioſity in the latter's grand and numerous collection, put all things in their proper places, and compoſed a moſt exact catalogue of them with infinite pains and labour, and a conſiderable loſs of time, which he ever after ſeverely regretted. The year following, MDCLXXI, having gone through this tedious and diſagreeable taſk, he was about publiſhing his treatiſe on the Chameleon and Hemorobion, or Day-Fly; but afterwards thought proper to defer the publication of thoſe pieces, ſo that they did not appear till the year LXXV, though

though he had formerly printed ſome part of them in Ruylenburgh, and even in France, ſo early as the year MDCLXVII.

On the firſt of May LXXII he ſent to the Royal Society of London three plates and ſix figures, in which he had repreſented the womb of a human ſubject, dedicating them at the ſame time to that learned body. To them he added ſome moſt curious drawings of the ſpermatic veſſels, the tube of the womb, and the ovary. All theſe curious pieces had been ſketched out in profeſſor Van Horne's houſe by the twenty-firſt of January, MDCLXVII, though not finiſhed or illuſtrated with proper explanations till the ſeventh of May MDCLXXI. Thus for the firſt time was publiſhed a ſpecimen of a method, by which both arteries and veins, and their fineſt ramifications, can be filled with a ceraceous matter, which not only renders thoſe parts perfectly viſible, but even incorruptible: and our author, to procure due credit to his drawing, ſent with them the uterus itſelf prepared according to this his new method. His motive in all this proceeding, was to have the opinion of learned and equitable judges of ſuch kind of performances. Another thing he had in view, was to convince the world that it was indebted to him as the firſt inventor, for the diſcoveries relating to the ſpermatic veſſels, which the celebrated Van Horne had before publiſhed in his Prodromus. But above all things, he by this means endeavoured to refute what Regnier de Graaf had written againſt him, with the greateſt bitterneſs, concerning ſome diſcoveries in regard to the organs of generation; and for this purpoſe he appealed to the judgment of the members of the Royal Society, to whom, as far as it concerned him, he gave full power and authority to decide the controverſy.

About this time he made a great many other very uſeful anatomical diſcoveries: in particular he diſſected a great number of fiſhes, with a view chiefly of diſcovering their liver, pancreas and melt; and in the courſe of his inquiries very often found in ſome a very large pancreas, with a great number of ſpacious and wide-mouthed ducts opening into the inteſtines: but above all things he applied himſelf with the greateſt diligence to find out by every trial that promiſed any ſucceſs, the true nature and properties of the pancreatic fluid, of which he ſent many bottles full to the celebrated Charles Drelincourt, then profeſſor of anatomy and phyſic in the univerſity of Leyden. All theſe particulars may be ſeen in the ſecond part of the Private College of Amſterdam, publiſhed by C. Commelin in the year MDCLXXIII; for there is ſcarce any thing in all that performance, for which the world is not indebted to our author; who there very mildly and modeſtly refutes de Graaf and Sylvius's accounts of the pancreatic fluid, though he formerly uſed to treat with great harſhneſs thoſe who contradicted his ſentiments, as appears in the literary controverſies he before this had maintained with de Graaf, Gaſper, Bartholin, and others. But religion and piety had by this time got the better of our author's warm and ſtubborn temper. Happening to read ſome books which the then famous Antonia Bourignon had a little before publiſhed, they made ſo great an impreſſion upon him, that a ſtrict compliance with all the duties of a good chriſtian was now become his principal concern. He began to hate and ſhun all thoſe things which men moſt covet and run after, but bent his endeavours more particularly to ſuppreſs the unruly paſſions of the mind, and above all that inſatiable ambition which makes us ſo deſirous of a ſuperiority over others, and which therefore, as the root of all evil, he was deſirous utterly to extirpate and deſtroy. All this time Antonia Bourignon happened to be in Holſtein, accompanied by John Tielens,

a native

a native of Amſterdam, with whom Swammerdam had been long acquainted. He therefore writ to his friend the eighteenth of March MDCLXXIII, to beg he might procure him Antonia's good will, and leave to write to her on his ſpiritual concerns; and having obtained this favour, he accordingly writ to her the twenty-ninth of April following, and received an anſwer to his letter dated the ſeventeenth of Auguſt. Her advice wrought ſo great a change in him, that at that time he thought of nothing but of obtaining from God a holy peace of mind, ſincerely grieving that he had loſt ſo much time in the ſervice of the world. After this he writ many more letters to Antonia, who very graciouſly anſwered them. About this time he was, if I am not miſtaken, the firſt that diſcovered a thing of very great importance, for he found that the hernia in both men and women never proceeds from a rupture of the peritoneum, but that the peritoneum alone is extended over the part where the ſeminal veſſels, encloſed in one caſe or ſheath, but which before this lay cloſe under the peritoneum, fall from it towards the ſcrotum. Now, if in this caſe the peritoneum happens to inſinuate itſelf into that wide paſſage, by which the ſpermatic cord falls down towards the teſtes, it there, whatever cauſe may preſs it, forms a ſacculus cæcus, or blind bag, on account of its wonderful extenſibility, and the ſmoothneſs of the cavity made for it by the deſcent of the ſpermatic cord. The ecphyſis once formed, grows larger and larger, as the cauſe which firſt produced it increaſes; and continuing to keep cloſe to the ſpermatic cord, follows it towards the ſcrotum, above the os pubis, and along the outſide of the muſcles. If this ecphyſis ſtops at the groin, it forms what is called a bubonoceles; but if it deſcends to the ſcrotum, an oſcheoceles; beſides which, it obtains a variety of other names, from the different ſubſtances that may happen to fall into it, ſuch as the omentum, the inteſtine, air or water. The ſame is the caſe in women, except that the deſcent is made along the femoral veſſels, (See Schraderi, Obſerv. Decad. II. Obſerv. IV. V.) where there is a very exact drawing to repreſent the nature of this diſorder. Many eminent perſons have ſince made pretenſions to the honour of this diſcovery, but the account I have given of it appears the moſt probable. In this book too there is another obſervation of our author equally important; for he there mentions his having ſeen two cicatrices in the ovary of a woman, that had been brought to bed of twins; which it is duely to be remarked happened at the ſame time. In the ſame collection there is our author's contrivance for preſerving the parts, or anatomical preparations in balſam. For all theſe reaſons, the editor thought proper to dedicate this work, publiſhed in MDCLXXIV, to Swammerdam, who was the chief contributor to it. Our author, moreover, in the year MDCLXXIII, had exhibited to the illuſtrious Arnold Syen, profeſſor of botany in the univerſity of Leyden, the ſeminal little bags of Fern, and the delineations he had made of them. I intreat the reader to view and conſider attentively the deſcriptions and figures contained in this book, and compare them with thoſe given a long time after by ſome of the greateſt botaniſts. There cannot be a greater reſemblance between two eggs, than there is between our author's performance this way, and thoſe that followed. The ſame things might have been ſeen in France, nor is it impoſſible that they might have been deſcribed there too. The laſt day of September of this year, our author finiſhed his treatiſe on Bees, which proved ſo fatiguing a performance, that he never after recovered even the appearance of his former health and vigour: and indeed it was an undertaking too great for the ſtrongeſt conſtitution, to be continually employed by day in making obſervations, and almoſt

almoſt as conſtantly engaged by night in recording them by drawings, and ſuitable explanations. This being ſummer work, his daily labour began at ſix in the morning, when the ſun afforded him light enough to ſurvey ſuch minute objects; and from that hour till twelve he continued without interruption, all the while expoſed in the open air to the ſcorching heat of the ſun, bearheaded, for fear of interrupting the ſight, and his head in a manner diſſolving into ſweat under the irreſiſtable ardors of that powerful luminary. And if he deſiſted at noon, it was only becauſe the ſtrength of his eyes was too much weakened, by the extraordinary afflux of light and the uſe of microſcopes, to continue any longer upon ſuch ſmall objects, though as diſcernible in the poſtmeridian, as they had before been in the antemeridian hours.

This fatigue our author ſubmitted to for a whole month together, without any interruption, merely to examine, deſcribe, and repreſent the inteſtines of Bees, beſides many months more beſtowed upon the other parts; during which time he ſpent whole days in making obſervations, as long as there was ſufficient light to make any; and whole nights in regiſtering his obſervations, till at at laſt he brought his treatiſe of Bees to the wiſhed-for perfection: a work which all the ages from the commencement of natural hiſtory to our own times, have produced nothing to equal, nothing to compare with it. Read and conſider it, and then judge for yourſelf. Our author, the better to accompliſh his vaſt unlimited views, often wiſhed for a year of perpetual heat and light to perfect his inquiries, with a polar night to reap all the advantages of them by proper drawings and deſcriptions. In his eſſay on the Hemorobion, or Day Fly, he ingenuouſly owns that this his treatiſe of Bees was formed amidſt a thouſand torments and agonies of heart and mind, and ſelf-reproaches, natural to a mind full of devotion and piety. On one hand his genius urged him to examine the miracles of the great Creator in his natural productions, whilſt on the other, the love of that ſame all-perfect Being deeply rooted in his heart, ſtruggled hard to perſuade him, that God alone, and not his creatures, was worthy of his reſearches, love and attention. The diſtreſs of mind our author felt upon this occaſion, was ſo ſevere that as ſoon as he had finiſhed his book upon Bees, he put it into the hands of another, without knowing or giving himſelf the leaſt concern about what might become of it. It appears however, that he at the ſame time wrote two letters to Paul Boccone, on the conſtruction of ſalt water or ſea ſtónes and corals, which are to be found in the nineteenth and twentieth letters of the ſaid Boccone's natural obſervations. After this Swammerdam grew almoſt altogether careleſs of the arts he had been hitherto fondeſt of. He had conceived this diſtaſte for wordly affairs above two years before, though he had ſtruggled againſt it in favour of his book on Bees; but now he could no longer allow his mind any other occupation beſides that of loving and adoring the Sovereign Good, to whoſe honour alone he openly declared, he began and directed his many and great labours in the cultivation of natural hiſtory, from which he now entirely deſiſted merely to devote all the little uncertain portion of life that remained, to the ſincere practice of every chriſtian virtue. His temperament was of the melancholy kind, which phyſicians have obſerved to be very firm in its purpoſes, and our author's natural diſpoſition was encreaſed by a quartan ague, ſo that he preſevered in his reſolution, in which the authority and advice of Antonia Bourignon fixed him beyond a poſſibility of relapſing into his former worldly way of thinking. He therefore reſolved to withdraw himſelf entirely from all converſation with the world, but had firſt the prudence ſeriouſly to examine, what would be neceſſary to maintain him in his retirement. This he found to amount yearly to four hundred Dutch florins or gilders, without having any thing but his curioſities to raiſe ſuch an income by. Theſe therefore he immediately reſolved to ſell, in hopes the produce of them put out to intereſt, would be ſufficient to anſwer his demands. The firſt he applied to on this occaſion, and the only perſon perhaps who knew any thing of our author's private intentions, was Thevenot, whom he requſted to publiſh and forward the ſale of thoſe things, which he had ſpent ſo much time and labour in collecting, and formerly ſo much loved. Thevenot did all that lay in his power to ſerve his friend, but to no purpoſe; for however valuable the treaſure, no one was to be found in France willing to purchaſe it, though our author was often flattered with the hopes of its ſelling to advantage. This diſappointment made Swammerdam apply to another friend. This was Nicholas Steno, who having renounced the religion of his country, was become a member of the church of Rome, had obtained a biſhopric as a reward for his change, and to induce him to continue in it, and now lived at the court of Florence. Swammerdam wrote to him to know if the grand duke was now as willing, as he had formerly been, to purchaſe his curioſities. In anſwer to this letter, the new convert's zeal made him uſe every argument he could think of to make our author, after his own example, conform to the church of Rome, and remove with his collection into Tuſcany, promiſing him for certain, that the great duke would let him have for his curioſities the price of twelve thouſand florins, which his highneſs had formerly offered, and let him want for nothing, that could make life eaſy and agreeable. But our author looked upon theſe conditional offers as the greateſt indignity that could be offered him, and accordingly bitterly reproached his friend Steno for endeavouring to prevail upon him in a manner he utterly deteſted, telling him withal that his ſoul was not venal; and Bourignon being conſulted on the occaſion, adviſed him by all means to reject Steno's propoſals. Our author agitated by ſuch a ſeries of hopes and diſappointments, made uſe of the little leiſure that remained on his hands, in arranging and adorning his curioſities; rendering them as durable as poſſible, and compoſing a complete catalogue of them, ſo that in his muſeum thus ſettled, the materials and the contrivance, the dignity of the ſubjects, and the vaſt pains taken in procuring, preparing, and exhibiting them, vied together for the preference. Theſe treaſures conſiſted chiefly of inſects and anatomical preparations from human ſubjects. The former our author ſet the higheſt value upon, and no wonder, as he had ſpent ſixteen years in collecting and preparing them, with infinite pains and expence. The ſight of his muſeum was alone ſufficient to prove, that what all former authors had publiſhed on this branch of natural hiſtory, amounted to nothing more than a dry catalogue of names, and ſome external figures, without affording any certain and uſeful knowledge. Whereas our author alone had collected near three thouſand ſpecies of inſects, that had no relation one to the other, and had examined every one of them, and diſpoſed them all in claſſes according to their real and natural characters; he had even diſſected many of them with that ſkill and dexterity peculiar to himſelf, and having with unwearied diligence traced them through every the leaſt period of their changes from the egg to the Butterfly, faithfully recording all his obſervations, taking care at the ſame to prepare and keep by him the minute originals as inconteſtable vouchers of his indefatigable induſtry in examining them, and his ſcrupulous veracity, relating

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what he had difcovered. Nay, that nothing fhould be wanting to perfect his difcoveries, he ufed himfelf to hatch, in a manner found out by, and only known to himfelf, the little eggs of infects, in order to difcover the obfcure manner of the exiftence of their firft rudiments, the progrefs of thefe rudiments to life, the firft motions of the infant animalcula, and by what endeavours they at laft broke their eggs, and opened themfelves a paffage into the world. While thus employed, he at length publifhed at Amfterdam the twelfth day of July MDCLXXV, his hiftory of the Ephemerus, or Day-Fly; which he began in France in the year LXIV, continued in Guelderland in the year LXVII, but did not perfect till this time, that he made it public. However even this, he did not attempt without Bourignon's approbation. This was the laft offspring of our author's great genius and application, after which he entirely renounced all thoughts of human affairs, to think of nothing but his fpiritual concerns, which he imagined he could not fo well promote in any other manner, as by going to confer perfonally with Bourignon. Accordingly, having firft obtained her leave for that purpofe, he fet out the autumn following from Amfterdam for Slefwick in Holftein, where fhe then refided, arrived there the thirtieth of September, and fpent fome time in her houfe. Mean while the Lutheran divines of that country, utterly averfe to Bourignon's undertakings, were for making her quit Holftein, which made her think of afking the king of Denmark's leave to take fhelter in his regal dominions. Swammerdam having taken upon him to execute this commiffion, fet out for Copenhagen, in company with another of her difciples, the twenty-fifth of March, MDCLXXVI. Here he faw Steno's mother, now far advanced in years, but reaped no other benefit by his journey, his Danifh majefty not thinking proper to grant Bourignon's requeft. After this our author made but a fhort ftay at Slefwick, from whence he fet out for Amfterdam the fixteenth of June following. On his coming home, he had the mortification of finding that his father's difpleafure at his paft conduct, inftead of being appeafed, was grown more violent on account of his late undertakings. Another and greater fubject of affliction was, the marriage of his fifter Joanna, who had hitherto kept houfe for her father fince he had buried his wife; for the father on this occafion had refolved to break up houfe-keeping, and to live for the future with his fon-in-law, Our author therefore now found himfelf under the fad neceffity of fhifting for himfelf by the month of May following. How great, alas! muft have been his diftrefs! He had neither money nor any thing of value except his mufeum, which he had already fo often endeavoured in vain to difpofe of; and his father did not propofe to allow him more than two hundred florins a year. On this occafion he formed a defign of retiring into the country, and flattered himfelf with the hopes of being able to provide for himfelf that way. The moft noble John Ort of Nieuwenrode Breukele, &c. had contracted a friendfhip of a very long ftanding with our author, and had often entertained him at his pleafant country feat with the greateft hofpitality and politenefs, and even invited him to remain there for good and all, and purfue his ftudies without interruption. But Swammerdam never till now found himfelf under a neceffity of putting his friend's fincerity to the teft; however he little expected the refufal he now met with, and which, as it convinced him of the little dependance to be had on the promifes of men, greatly contributed to increafe his former anxiety. But his father dying this year put an end to his troubles, by leaving him a fufficiency to live, in a manner fuitable to his own inclinations, for now he faw himfelf freed from all

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buſineſs, but that of ſerving God, which alone he delighted in. But his joy was ſoon interrupted, when the father's fortune came to be divided, and his muſeum to be diſpoſed of, the ſiſter claiming more of the inheritance than came to her ſhare, and the chief direction of the ſale, while Swammerdam for the ſake of peace and quietneſs, and in order to get the ſooner into his long wiſhed for retirement, ſubmitted to her unjuſt pretentions. Nevertheleſs, the vexation attending this family ſtrife, joined to the uninterrupted fervour of his devotion, brought a tedious diſorder upon him. This was a double tertian ague, which afterwards continued without intermiſſion, and then changed in different manners. Whilſt this fit of ſickneſs continued, he got up but ſeldom in the day time, and for three months together that the ſlow fever continued, he never went out of his houſe; he was even a whole twelve month without making a ſingle experiment. At laſt his diſorder, again changing to a tertian ague, ſeemed to abate, and then entirely left him for ſome days. His friends nevertheleſs, and among them doctor Matthew Slade, a moſt learned phyſician, and one whoſe advice had the greateſt weight with our author, could never prevail upon him to ſtir from his bed-chamber. He would often excuſe himſelf by ſaying that ſolitude and retirement could alone extirpate the relicks of his diſorder; when Slade, Ruyſh, Schrader, Hotton and Guenellon, who all of them frequently viſited him in the quality both of friends and phyſicians, attempted to perſuade him to the uſe of medicines and freſh air for the recovery of his former ſtrength and vigour. But he at laſt put a ſtop to their importunities by an obſtinate ſilence. However as the things he formerly took moſt delight in, were now become odious to him, and he had no further hopes of being able to diſpoſe of them in France, he wrote to his friend Thevenot, who had again invited him to his houſe, that he would accept of his kind offer, provided he would immediately diſpoſe of his curioſities for him, and permit him to live quite unknown and retired. But here too our author was again diſappointed, ſo that at laſt he advertiſed a fixed day in the month of May following, MDCLXXX, for the ſale of his curioſities, article by article, to the beſt bidder; ſo great a deſire he had of getting rid of them, notwithſtanding that he had ſeen that his father's muſeum, when ſold in ſingle lots, had not produced above a ſixth part of what his executors expected it would have ſold for. But whilſt our author was taken up in this manner, his old diſorder broke out anew with worſe ſymptoms than had hitherto appeared, an emaciated countenance, hollow eyes, a ſlow continued fever which eating always increaſed, and a ſwelling in his feet, legs, thighs and belly, attended with conſtant and uninterrupted pains. All this time his friends durſt not make the leaſt mention before him of his former ſtudies, nor did he himſelf ever ſpeak a word of them; for he now utterly deteſted as vain and inſignificant the things he formerly moſt delighted in. Thevenot, informed of the languiſhing condition he was in, offered him the jeſuit's bark, then greatly talked of for its efficacy in curing fevers, and Swammerdam deſired he might ſend him ſome of it, and ſome ſpecific againſt the dropſy, if he knew of any. But at laſt finding himſelf grow worſe and worſe, he made his will the twenty-fifth of January MDCLXXX, and left Melchiſedeck Thevenot, formerly the French king's miniſter at Genoa, all his original manuſcripts belonging to the natural and anatomical hiſtory of Bees and Butterflies, with fifty-two plates belonging to them, and ordered all thoſe valuable papers then laid up in the houſe of Herman Wingendorp at Leyden, to be delivered to the legatee within a year after his death; but earneſtly recommended that his treatiſe on

Bees

Bees ſhould be publiſhed in Dutch as well as Latin, as diſplaying the wiſdom and power of God in ſo particular a manner. The little portion of life, that he enjoyed after this diſpoſal of his worldly concerns, he gave entirely to his ſpiritual ones, ſpending his whole time in acts of love and adoration of the Supreme Being, and thus ended his courſe the ſeventeenth of February following. He conſtituted Magaret Volckers, wife of Daniel de Hoeſt, doctor of phyſic, his heireſs, and her and Chriſtopher Van Wyland his executors, but Van Wyland dying ſoon after, the truſt devolved wholly into the hands of Madam Volckers.

As ſoon as our author's executors had performed the laſt rites due to their deceaſed friend, Mr. Ort at their requeſt gave Mr. Thevenot notice of the legacy left him in Wingendorp's hands; for Swammerdam being little verſed in the Latin, in which notwithſtanding he was deſirous of ſeeing all his works publiſhed, had given them to Wingendorp to tranſlate into that language, as he had before done our author's writings on the uterus. Thevenot on this wrote ſeveral times to doctor de Hoeſt, to deſire he ſhould immediately cauſe his legacy to be delivered him; but Wingendorp, who was poor, and lived by his tranſlations into various languages, after endeavouring by a thouſand frivolous pretexts to make a property of what he had only been entruſted with, at laſt openly declared he would return nothing till compelled to it by due courſe of law. Upon this therefore a tedious and troubleſome lawſuit enſued, in which however Thevenot at laſt obtained a decree in his favour in May MDCLXXXII, when Swammerdam's papers in the hands of Wingendorp were delivered to Burcher de Volder, a celebrated profeſſor of anatomy and mathematics, whom Thevenot had engaged as a friend to take his intereſt in hand, and without whoſe diligence and prudent management, it is poſſible that Thevenot would have loſt his legacy. As ſoon as Thevenot heard of his friend's ſucceſs, he gave orders to have the writings in queſtion publiſhed in Dutch, but ſoon altered his opinion, and ſent for them. He then attempted ſome alterations in them, as I could diſcover by the eraſements made here and there with his own hand; but in this he fell ſhort of anſwering Swammerdam's intentions, though probably only for want of abilities ſuitable to ſuch a taſk. Be that as it will, this valuable treaſure, after Thevenot's death, was purchaſed by Joubert the king's painter, whoſe heirs afterwards ſold it at the inconſiderable price of fifty French crowns to the illuſtrious Joſeph du Verney, with whom they lay hid and diſregarded for a long time. At laſt a report prevailing that the anatomy of inſects was coming into great vogue, and that a hiſtory of this part of the creation, compoſed by the great anatomiſt juſt now ſpoken of, was upon the point of appearing at Paris, I requeſted William Sherard my gueſt at that time, and moſt intimate friend, to obtain ſome certainty for me in regard to this report, as he was then about making a journey into France. Accordingly on his arrival at Paris, he wrote that Swammerdam's works were in the hands of Monſieur du Verney, and even ſent me ſome copper-plates after the drawings of our author, which when I examined, ſerved only to excite my ambition of aſſerting the right of my country to the honour of having produced the originals, and making without loſs of time all the inquiries I judged neceſſary for that important end. At laſt, by the aſſiſtance of the reverend Mark Guitton, and the eminent William Roell, profeſſor of anatomy at Amſterdam, both then reſiding in Paris, I ſo far ſucceeded, that they were purchaſed for me the twenty-ſixth of

 March,

March, MDCCXXVII, at the price of one thouſand five hundred French florins, and I received them complete the ſame ſummer. As ſoon as I had got them, I read them; and having diligently examined them more than once, I carefully digeſted them, and had the ſatisfaction of ſeeing that nothing was wanting except a few pages of the text in the treatiſe of Bees, which a note in the margin obſerved was not to be repaired; however, on looking narrowly for them, I had the good fortune of finding them elſewhere. Upon this, I ſhould have publiſhed them directly, but for the inſatiable avarice, and unbounded audaciouſneſs of the printers, who make nothing of reprinting things as ſoon as they appear, to the great loſs of the firſt publiſhers. However, I have at laſt ſucceded in guarding againſt ſuch foul treatment, and return my hearty thanks to all thoſe who ſo generouſly contributed their aſſiſtance on this occaſion. And now I muſt own, that it is with the greateſt pleaſure I find myſelf enabled by this valuable work to challenge all thoſe nations, who ſo liberally reproach us Dutchmen with a dullneſs that requires the inventions of others to ſharpen it, to produce before able judges, any thing equal to this performance of one of our countrymen. This inſtance will, I believe, be ſufficient to convince mankind that we have among us uncommon geniuſes, who have made the moſt important diſcoveries, and ſpider-like, have furniſhed themſelves alone both the workmanſhip and materials. However I muſt in juſtice own, there is now in France ſuch another bright ſun, who by his light not only ſhews, but adds grace and dignity to every object he is pleaſed to ſhine upon. I mean that prodigy of our age, and glory of his country, the illuſtrious Reaumur. God grant this great man life to go through, and many years to ſurvive, his great undertaking.

I examined with the greateſt care and attention all the letters, and other writings of Swammerdam, that I could lay my hands on, in order to find out the methods taken by him to perfect thoſe beautiful diſcoveries, by which he has ſo far exceeded all authors in the ſame way; and I ſhall here candidly relate the fruits of my perquiſition. For diſſecting of very minute ſubjects, he had a braſs table made on purpoſe by that ingenious artiſt Samuel Muſſchenbroek. To this table were faſtened two braſs arms, moveable at pleaſure to any part of it, and the upper portions of theſe arms were likewiſe ſo contrived as to be ſuſceptible of a very ſlow vertical motion, by which means the operator could readily alter their heigth as he ſaw moſt convenient to his purpoſe. The office of one of theſe arms was to hold the little corpuſcle, and that of the other to apply the microſcope. His microſcopes were of various ſizes and curvatures; his microſcopical glaſſes being of various diameters and focuſes, and from the leaſt to the greateſt, the beſt that could be procured, in regard to the exactneſs of the workmanſhip, and the tranſparency of the ſubſtance. His way was to begin his ſurveys with the ſmalleſt magnifiers, and from thence proceed by degrees to the greateſt; and by nature and uſe was ſo incomparably dexterous in the management of theſe uſeful inſtruments, that he made every obſervation ſubſervient to the next, and all tend to confirm each other, and complete the deſcription. Theſe no doubt were talents very uncommon, though no leſs requiſite in an obſerver of ſuch things. But the conſtructing of very fine ſciſſors, and giving them an extreme ſharpneſs, ſeems to have been his chief ſecret. Theſe he made uſe of to cut very minute objects, becaufe they diffected them equably; whereas knives and lancets, let them be ever fo fine and fharp, are apt to diforder delicate fubftances, as in going through them they generally draw after them, and difplace, fome of the filaments: his knives, lancets, and ftyles were fo very fine, that he could not fee to fharpen them without the affiftance of the microfcope; but with them he could diffect the inteftines of Bees with the fame accuracy and diftinctnefs, that others do thofe of large animals. He was particularly dextrous in the management of fmall tubes of glafs no thicker than a briftle, drawn to a very fine point at one end, but thicker at the other. Thefe he made ufe of whenever he had a mind to fhew, and blow up the fmalleft veffels difcovered by the microfcope; to trace, diftinguifh, and feparate their courfes and communications, or to inject them with very fubtil coloured liquors. As to the infects themfelves, he ufed to fuffocate them in alcohol or fpirit of wine, in water, or fpirit of turpentine, and likewife preferved them for fome time in thefe liquids, by which means he kept the parts from putrefying, and confequently collapfing and mixing together; and added to them, befides, fuch ftrength and firmnefs, as could not fail of making the diffections far more eafy and agreeable. When he had divided tranfverfely with his fine fciffors the little creature he intended to examine, and had carefully noted every thing that appeared without further diffection, he proceeded to extract the vifcera in a very cautious leifurely manner, with other inftruments of equal fubtility; but firft took care to wafh away and feparate with very fine pencils the fat with which infects are moft plentifully fupplied, and which always occafions fome damage to the internal parts, before they can be extracted. This laft operation is beft performed upon infects whilft in the Nymph ftate. Sometimes he put into water the delicate vifcera of the infects he had fuffocated, and then fhaking them gently, procured himfelf an opportunity of examining them, efpecially the air veffels, which by this means he could feparate from all the other parts whole and entire, to the great admiration of all thofe who beheld them; as thefe veffels are not to be diftinctly feen in any other manner, or indeed feen at all without damaging them. He often made ufe of water injected by a fyringe, to cleanfe thoroughly the internal parts of his infects, then blew them up with air and dried them; by which means he rendered them durable, and fit for examination, at a proper opportunity. Sometimes he has examined with the greateft fuccefs, and made the moft important difcoveries in infects that he had preferved in balfam, and kept for years together in that condition. Again, he has frequently made punctures with a fine needle in other infects, and after fqueezing out all their moifture through the holes made in this manner, filled them with air by means of very flender glafs tubes, then dried them in the fhade, and laft of all anointed them with oil of fpike, in which a little refin had been diffolved, by which means they retain their proper forms for a very long time. He had fo fingular a fecret for preferving the very nerves of infects, that they ufed to continue as limber and as perfpicuous as ever they had been. As to Worms in particular, his way was to make a fmall puncture or incifion in them towards the tail, and after having very gently, and with great patience fqueezed out all their humours, and great part of their vifcera, inject them with wax, fo as to give and continue to them all the appearances of living, healthy, and vigorous creatures. He difcovered that the fat of all infects was perfectly diffolvible in in oil of turpentine, and that they could not be preferved in balfam: and this difcovery he always made the greateft fecret of, becaufe the fat of infects when melted, and then dried, looks like lime fcattered over the parts, fo as to obfcure the vifcera, and make it utterly impoffible to examine them; but then, however confufed and immerfed they might have been before, they fhew themfelves after this procefs very plainly and diftinctly, on being long and thoroughly wafhed with fair water. Very often he fpent whole days in cleanfing of its fat in this manner, the body of a fingle Caterpillar, in order to difcover the true conftruction of that infect's heart. His fingular fagacity in ftripping off the fkin of Caterpillars that were upon the point of fpinning their nefts, deferves particular notice. This he effected by letting them drop by their threads into fcalding water, and fuddenly withdrawing them, for by this means the epidermis peeled off very eafily; and when this was done, he put them into diftilled vinegar and fpirit of wine mixed together in equal portions, which, by giving firmnefs to the parts, gave an opportunity of feparating them with very little trouble from the exuviæ or fkins, without any damage to the vifcera, fo that by this contrivance the Nymph could be fhewn wrapped up in the Caterpillar, and the Butterfly in the Nymph. All thefe wonders he performed by the light of the brighteft mid-day fun, and had brought his arts to fuch perfection, that he could exhibit whenever he thought proper, the manner in which infects were enclofed in infects, and were to be extricated from their enclofures. He could at laft change the Caterpillar to a Chryfalis at his pleafure, and alfo could as he pleafed forward, ftop, and regulate its motions. He affirmed nothing but what he faw, and was able to demonftrate every thing he affirmed. He in good earneft followed Lord Bacon's advice; for his opinions were the fruit of his experience, and he could effect the very things, whofe exiftence he maintained. Obfervations alone, made with the moft wonderful patience by experienced fenfes, affifted with the fitteft inftruments, led him into the method followed by nature in all her operations; and he fo fcrupuloufly adhered to that great guide, that whenever he formed a rule from particular obfervations, he did it with fo much caution, as to let it include thofe particulars only, from which he had deduced it, and extracted his canon. In explaining the works of nature, he ufed to reafon by comparing his obfervations with one another, and never admitted the ufe of a general application of them upon any other occafion. Thus he began, carried forward, and perfected without any affiftance, in a private and middling ftation of life, more difcoveries than all the writers of all the preceding ages. By thefe means he found there were little creatures that breathe at the tail, and others that govern themfelves in the water by the help of a little bubble of air, which they expand at pleafure to afcend to the furface, and comprefs in like manner, when defirous to fink to the bottom; and can regulate it in fuch a certain manner, that they can fufpend themfelves in any part of the water they choofe. Some again he difcovered, who have their legs fixed to their jaws; and others in which the penis of the male receives in copulation the vulva of the female, and a few which are of both fexes at once, and act reciprocally upon each other as fuch at one and the fame time. In fine, from fuch an infinite number of new and uncommon obfervations, he formed a fyftem fuperior by many degrees to any thing of the kind that had as yet appeared. He even collected the materials upon which this fyftem was founded, rendered them durable, and digefted them, in order to have always at hand undeniable vouchers for the truth of

every

every thing he advanced. Such a fabrick had never been raiſed before, yet it was raiſed by him in ſo maſterly a manner, that it might have ſtood ages. But, O hard fate of induſtry! after having been driven himſelf to offer his curioſities to ſale more like a beggar that had nothing to give, than like a man who offered infinitely more than he aſked, and this too without ſucceſs; his heirs, after his deceaſe, made propoſals of ſelling them all, his anatomical preparations, his inſects, and his inſtruments, for the trifling ſum of five thouſand florins, without finding any one intelligent enough to buy them for his own uſe, or generous enough to purchaſe them for that of the public. Alas, what a loſs was this, never to be repaired! Theſe wonders of art and nature, by being ſeparated and ſcattered into different hands, loſt all their value, to the irretrievable diſhonour of an age, the moſt remarkable of any that had as yet ever been for ſtudies of this nature. As for you, my readers, I muſt inform you of the obligations you owe, on the preſent occaſion, to the great Gaubius, who from his ſincere love to the republic of letters, tranſlated all the works I now preſent you, from the original Dutch into Latin, that the curious of all nations might have the better chance of reading them; and perhaps it would have been a hard matter, if not impoſſible, to find another tranſlator equal to the taſk. The facts I have here related are collected from the hiſtory of the times, from a repeated peruſal of Swammerdam's works, and from the letters written or received by him. An accurate and well-digeſted collection of all theſe papers ſupplied me with materials for writing his life, and I intend to depoſit them all, as well as the original drawings made by his own hand in the moſt elegant and maſterly manner, in the public library of the univerſity, there to remain as an eternal monument of our author's merit, and of my exactneſs and integrity in writing his life, and publiſhing his labours; and, in fine, that ſuch as take delight in things of this kind, may by this means have an eaſy opportunity of ſatisfying their curioſity. It was thus I acted in regard to the poſthumous works of the celebrated Vaillant. Farewel reader.

LEYDEN, 17$\frac{11}{9}$35.

HERMAN BOERHAAVE.

THE

AUTHOR's PREFACE.

CURIOUS reader, before I proceed to lay my obſervations before you, I muſt moſt humbly requeſt, that you will not be diſpleaſed, if in all this work I have only made uſe of my own obſervations, as a ſolid and immoveable foundation to build upon, and that from them I have deduced certain concluſions, ſolid theorems, and claſſes digeſted in due order. For as long as neither nature herſelf exhibits any thing in oppoſition to theſe theorems, nor other writers produce experiments to contradict them; we may reſt aſſured of the truth of what I have delivered; but then we muſt not wander beyond the limits of ſuch obſervations, nor by ſtraining them too much, make them extend to things not as yet ſufficiently diſcovered. Otherwiſe, as nature is utterly inexhauſtible, we ſhould be in danger of falling into errors; and indeed it is generally our own fault that things of themſelves ſufficiently clear and evident, become obſcure, and even impenetrable to us. Thus a perſon would be guilty of a great miſtake, who, after running over all the animals he knew, never to be at once male and female, ſhould from thence conclude, that both ſexes are never found in one and the ſame ſubject; whereas the contrary appears in Snails, which are all capable of impregnating as males, and conceiving as females, but with this reſtriction, that the ſame Snail cannot act upon itſelf; ſo that a mutual intercourſe of two is requiſite to carry on the buſineſs of propagation, as I many years ago demonſtrated before a numerous company. As therefore all the experiments I have hitherto made, agree perfectly together, and mutually ſupport each other, there is the leſs reaſon, till ſomething appears in the nature of things to break the thread of my ſyſtem, to be ſtartled at the objections of others, who never made the ſame obſervations, and are not perhaps properly qualified to make the ſame experiments. But if hereafter any thing ſhould occur, that I may have reaſon to think deſerves to be added to what I have already advanced, or exceeds the bounds to which I have confined myſelf, or appears repugnant to my former obſervations; I promiſe faithfully to publiſh them, though they ſhould abſolutely deſtroy the principles I have laid down, provided that they ſerve to confirm and illuſtrate the truth. And I moreover earneſtly requeſt all thoſe who love truth as I do, and are equally anxious to find it out, to aſſiſt me on this occaſion with their favour and advice.

But as the moſt eminent amongſt the ancient writers on this branch of natural hiſtory, have propoſed two different manners in which inſects undergo their mutations; one known by the name of Nymph, and the other by that of Chryſalis, calling Nymph that change of the Worm, under which it exhibits the form of the inſect that is to iſſue from it; and Chryſalis, that other change which ſhews no ſigns of the future inſect; I muſt

forewarn

forewarn my readers that I ſhall by no means admit two different ſpecies of changes, as I can plainly and diſtinctly diſcover in the Chryſalis, as well as in the Nymph, all the parts of the future inſect, and can even give ocular proof of their exiſtence. And as to the parts not appearing externally in the Chryſalis as clearly as they do in the Nymph, and the former having a gold colour, which I never obſerved in the latter, it is not a thing of conſequence enough to make me alter my opinion.

But perhaps the reader, as yet a novice in the hiſtory of inſects, may not rightly underſtand what I mean by the words Nymph and Chryſalis, I muſt refer him to the figures of this work, where he will find the Nymph of the Ant repreſented under number v. Tab. XVI. and the Chryſalis of the nocturnal Butterfly, under the ſame number v. Tab. XXXIII. For the ſake of greater perſpicuity, I obſerve the ſame order in Tab. I. XII. and XXXVIII. where I place before my readers other ſpecies of Nymphs that ſhall be deſcribed in their proper places, and afterwards ſummed up under one view, in the general compariſon of mutations, with which I intend to conclude this work. Farewell.

E L E G I A

IN HONOREM

D. JOANNIS SWAMMERDAMII, M.D.

Naturæ Inſectorum Indagatoris indefeſſi, incomparabilis.

Allocutio ad Harveum τ̃ πάνυ.

FLOS & honos Angliæ gentis, quo, judice Phœbo,
   Nil quicquam eximius terra Britanna tulit;
Artis delicium noſtræ, quo ſoſpite quondam
   Sidera tangebat vertice celſa ſuo;
Deſine jam gemitus, tua jam ſuſpiria ceſſent,
   Quod multa abſtulerit ter ſcelerata manus,
Quêis miranda tibi levium ſpectacula rerum
   Scripta, atque in varios corpora verſa modos:
Quêis tibi Nympharum & fulvæ Chryſallidos ortus
   Depicti, & Gryllus papilioque fuit:
Ecce alium, data damna tibi qui ſarciet olim,
   Inventiſque addet non tibi viſa tuis.
Non hunc parva latet magni Formica laboris,
   Anguſto quamvis tramite carpat iter.
Hic quis amor, quis Hymen illis, quæque oſcula novit,
   Quâ foveant natos ſedulitate ſuos:
Non fugit hunc miſera & male nata Diaria, quamvis
   Vix detur medium vivere poſſe diem;
Quæ poſtquam teneris volitavit in ære pennis,
   Sævis præda avibus, piſcibues eſca cadit.
Nec Scarabæus aquæ, ſeu pervolat ille paludem,
   Seu celer, ad fundum, mox rediturus, abit;
Sed bullâ, mirum viſu! rediturus inani,
   Quam villoſa intus caudula cluſa tegit.
Nec tu, dire Culex, mediis ſeu degis in undis,
   Aëra ſeu pinna liberiore petis.
Novit Apum ſexus, ortus, connubia, novit
   Quam telam in cera ſedula fingat Apis.
Et negat ulla novas Inſecta aſſumere formas,
   At vermi incluſas delituiſſe docet.
Quam ſtupui, quando narrantis ab ore pependi,
   Cum mihi monſtraret plurima quam ſtupui!
Gaude, Vegta, tuis illum quod vexeris undis,
   Et quod capta tuo flumine præda fuit.
Non Aldrovandos jam clara Bononia jactet,
   Nec mihi Moufetos Anglus ad ferat:
Geſneros etiam ſileat Germania tellus,
   Neſcio quid majus Terra Batava dabit.

Cecini amico amicus

MATTHÆUS SLADUS, M. D.

Ἐις ΣΩΑΜΜΕΡΔΑΜΟΝ περὶ Εφημέρου ἐντόμου

βιβλιόν ἐκδιδόντα.

Πρὸς ἀναγνώστην.

Τήν δ' ὅτταν γνῴης καὶ ἀναγνῴης, φίλε, βίβλον,
  Σουαμμερδᾶμος τὴν τέκεν εὐφραδέως,
Ἐντόμου ἥ σε φυὴν ἀλλοιώσεις τε διδάσκει
  Ἦμαρ τῷ σφετέρην δῶκεν ἐπωνυμίην.
Μὴ καταγινώσκῃς πόνον αὐτοῦ. ἀλλὰ σεαυτὸν
  Γνῶθι, καὶ αὐτὸς ἐὼν μάνθαν' ἐφημέριος.

Idem utcunque Latinè redditum.

Ad Lectorem.

Videris ut, Lector, librum & perlegeris, ingens
  Quem Swammerdammi cura laborque dedit;
Quo tibi natura Insecti moresque patescunt,
  Unica cui nomen donat habere dies.
Negligere illius curam fuge. Noscere at ipsum
  Te cupe, quamque fugax ipse brevisque fies.

M. Sladus, M. D.

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C O N T E N T S.

P A R T I.

PART II.

The

C O N T E N T S.

THE

BOOK of NATURE;

OR, THE

HISTORY of INSECTS.

CHAP. I.

The defign and diftribution of the work.

AFTER an attentive examination of the nature and fabrick of the leaft and largeft animals, I cannot but allow the lefs an equal, or perhaps fuperior degree in dignity. Whoever duly confiders the conduct and inftinct of the one, with the manners and actions of the other, muft acknowledge all are under the direction and controul of a fupreme and fingular intelligence; which, as in the largeft, it extends beyond the limits of our comprehenfion, efcapes our refearches in the fmalleft. If, while we diffect with care the larger animals, we are filled with wonder at the elegant difpofition of their limbs, the inimitable order of their mufcles, and the regular direction of their veins, arteries, and nerves; to what an height is our aftonifhment raifed, when we difcover all thefe parts arranged in the leaft, in the fame regular manner. How is it poffible but we muft ftand amazed when we reflect that thofe animalcules, * whofe little bodies are fmaller than the fineft point of our diffecting knife, have mufcles, veins, arteries, and every other part common to the larger animals? Creatures fo very diminutive, that our hands are not delicate enough to manage, or our eyes fufficiently acute to fee, them; infomuch that we are almoft excluded from anatomizing their parts, in order to come at the knowledge of their interior conftruction. Thus, what we know of the fabrick of thofe creatures reaches no farther than to a fimple enumeration of the parts which we have before obferved in larger creatures. We are not only thus in the dark, in attempting a difcovery of the conftruction of the leaft animalcules, but we even gain very little knowledge of the wonderful texture of the vifcera of the largeft animals: for as the point of our diffecting knife is not minute enough to feparate the tender parts of the fmall animals, it is not lefs unfit to be ufed in difcovering the extremities of the nerves and veins in the larger.

As our knowledge of both fpecies of animals is fo far limited by our ignorance, and as we have not hitherto had fuch a fufficient number of experiments as are neceffary to form a proper judgment of their elegant ftructure, and the admirable difpofition of their parts, we may eafily fee how rafh and precipitate their opinion is, who efteem the larger creatures only as perfect, and the lefs as fcarce worthy to be claffed with animals; but, as they fay, produced by chance, or generated from putrefaction; rendering, by fuch reafoning, the conftant order of nature fubject to chance. But as it happens to the fmalleft of animals, for inftance, to thofe produced from the egg of the Acarus which is fo minute, as fcarcely to be vifible, fo alfo it is with the largeft animals; their origin is not more obvious or more vifible, perhaps it is rather more obfcure, and they derive their being from a lefs vifible beginning. Nor let any man imagine that I fay this without conviction, fince I have found by diligent inquiry that the largeft animal is not in its firft formation bigger than the rudiment of an Ant; and therefore, unlefs the Great Creator had fet certain bounds to the growth of every kind, which it cannot exceed, I fee no reafon why the Ant might not furpafs in bulk the largeft. Perhaps, their fizes proceed in proportion to the greater or lefs ftrength of the heart, by which the parts muft be extended, againft the preffure of the atmofphere. Notwithftanding the fmallnefs of

* We are accuftomed to ufe the word animalcule, to exprefs thofe minute creatures in particular, which are only feen by the affiftance of microfcopes; this author applies it to fmall animals in general, which was its original, and is its more proper, meaning.

Ants, nothing hinders our preferring them to the largeſt animals, if we conſider either their unwearied diligence, their wonderful ſtrength, or their inimitable propenſity to labour; or, to ſay all in one word, their amazing and incomprehenſible love to their young, whom they not only carry daily to ſuch places as may afford them food, but, if by accident they are killed, and even cut into pieces, they, with the utmoſt tenderneſs, will carry them away piecemeal in their arms. Who can ſhew ſuch an example among the largeſt animals, which are dignified with the title of perfect? Who can find an inſtance in any other creature, that may come in competition with this? But in the entrance of this work it is not my intention to explain the form and wonderful propagation of animalcules, which ſeem to be exanguious or to have no blood: I ſhall treat in general of the manner of their ſurpriſing metamorphoſes; and at the ſame time ſhew, that they not only reſemble other animals in the increaſe of their parts, but that they exceed them by infinite degrees. This being done, the particular obſervations concerning thoſe animalcules ſhall be fully explained in their proper order and place. But before I proceed to them, it will be neceſſary to prefix a general diſſertation on their nature.

That I may make good the promiſe which, twelve years ago, I made to the public in the preface to my book of Reſpiration, (and which I have been unhappily hitherto hindered from fulfilling by ſickneſs, and other impediments,) I am now to ſhew the particular change of the Caterpillar into a Chryſalis; as alſo, the nature and various forms of thoſe animalcules, which are ſaid to be exanguious, before and after their change into Nymphs: but I judge it extremely neceſſary to eſtabliſh firſt ſome certain propoſitions, and to explain the order of their changes. This, fully underſtood, will contribute to a clear and diſtinct perception of the irregular and various appearances of inſects; ſupplying the place of a pencil, and repreſenting, as it were, in their true colours, the variations of them; ſetting each in a juſt light, and in their native dreſs. Thus ſome certain and fixed principles will be ſupplied to the ingenious, who are curious in theſe things; and the obſervations, of which I ſhall give a conſiderable number, will remain as a firm foundation and ſure ſupport for all thoſe experiments that ſhall be made concerning them, or all that poſſibly can be made. Nor does it appear to me a matter of ſmall moment to have diſcovered rules and theorems in the nature of things, by the aſſiſtance of which all thoſe metamorphoſes of inſects, which have the appearance of fiction and fancy, and differ in form and ſtructure infinitely from each other, are reduced to one foundation and kind only; including in three or four orders of changes all the various ſpecies. This may be perceived in the firſt rudiments of thoſe creatures which appear to us under the form of eggs.

The true nature of the metamorphoſes of theſe animalcules ſeems to have been ſubject to the fate of ſome valuable picture, which, by length of time, being ſoiled and clouded with dirt, no longer ſhews the true form of its figures, but has an appearance altogether different; ſo that it muſt be cleaned, and its original luſtre reſtored, if we would diſcover its true appearance. In the ſame manner here, before we can explain the poſitions and the ſeries of the changes, and illuſtrate them by particular examples, it is neceſſary we ſhould reſtore this excellent appearance, or, if I may ſo ſpeak, that curious picture, exhibiting the natural forms of inſects: which, by the learned as well as others, through length of time, has been ſo ſoiled and obſcured, that the beautiful and genuine changes of thoſe animalcules do not appear properly what they are, but rather ſomewhat elſe, or at leaſt, are ſeen in a confuſed manner. Theſe muſt therefore be cleared from the falſe traditions of philoſophers, by our theorems, as by the genuine tinct of nature, and reſtored to their native beauty.

We ſhall now proceed to the four diſtinct things which are to be treated of in this work. In the firſt place, we ſhall conſider the Nymph as the original ground of all the transformations of inſects, or exanguious animals; but, leſt any one ſhould miſtake the uſe of the word transformation, I here add, that both in this, and in every other part of the enſuing work, I intend no more by that term, than the gradual and natural growth of thoſe creatures. Secondly, we ſhall ſhew by what means it has happened, that the knowledge of the Nymph, or original ground of thoſe natural changes, has been ſo obſcured and darkened. This we ſhall take care to clear up and reſtore to its former ſtate. Thirdly, we ſhall eſtabliſh four ſeries or orders of thoſe changes, taken from nature, to which all the metamorphoſes of the exanguious animalcule may be referred, as depending only upon one foundation. Laſtly, the order of the natural changes of their parts will be confirmed by particular examples in the inſects themſelves, together with the figures of them, and the whole clearly and diſtinctly explained.

CHAP.

CHAP. II.

The single foundation of the changes observable in the known insects shewn to be the Nymph; with an explanation of the manner in which worms and Caterpillars become Nymphs.

THOUGH, amongst all the mutations of nature which deserve our attention, none appears more surprizing to the generality of mankind, than that by which a Caterpillar assumes the form of a winged animal, it in reality deserves no more admiration, than any other change in the forms of Bees, or the transformation observable in plants. This will evidently appear to any one, who, having examined the real nature of such metamorphoses, will observe how exactly they agree, not only with the growth of animals which undergo no such change; but also with the shooting or budding out of plants and flowers. Whatever difficulty we find in this, is merely an effect of our own mistaken notions; and our admiration arises from our ignorance of the nature of the Nymph or Chrysalis. In this the little animal lies, like the flower in its bud. Before I proceed farther on this head, it may be proper to observe, that these words, Nymph and Chrysalis, signify the same thing, and that there is no difference in the nature of the subjects to which they are applied.

To advance toward my purpose, I must repeat, that the reader is to take particular notice, that to acquire a satisfactory knowledge of the mutations which happen in the eggs of insects in general, as well as in the worms or Caterpillars in particular hatched from them, he must first clearly and distinctly comprehend the nature of the Nymph, Necydalis, Chrysalis, or Aurelia. Though we must allow that there appears, as it is generally called, some accidental difference between the plain unadorned Nymph, and that form of it, which, from its bright gold colour, is called an Aurelia, or Chrysalis; upon muture considerati-on, this will be found merely accidental, without any difference in the internal constitution of their parts, sufficient to alter in them what is commonly called the essence of things. This great truth being once understood of insects in general, may be afterwards applied to every particular species of them: for instance, to the Silk-worm, whose Nymph or Necydalis is never called Nymph by naturalists; but only Necydalis and Chrysalis, though it is in fact a Nymph, and is called Chrysalis merely on account of the external difference in colour.

That we may succeed the better in examining the nature of this Nymph, or Chrysalis, upon which, as upon an immoveable basis, the doctrine of all the changes observable in insects is so evidently founded, that the jarring opinions of all the naturalists who have hitherto wrote upon the subject, must appear utterly vain; it is necessary to observe, that the Nymph, or Chrysalis, is nothing more than a change of the Caterpillar or worm; or, to speak more properly, an accretion, growth, or budding of the limbs and parts of the Caterpillar or worm, containing the embryo of the winged animal that is to proceed from it. The Nymph, or Chrysalis, may even be considered as the winged animal itself hid under this particular form. From whence it follows, that in reality the Caterpillar, or worm, is not changed into a Nymph or Chrysalis; nor, to go a step further, the Nymph or Chrysalis into a winged animal; but that the same worm or Caterpillar, which, on casting its skin, assumes the form of a Nymph or Chrysalis, becomes afterwards a winged animal. Nor, indeed, can it be said that there happens any other change on this occasion, than what is observed in chickens, from eggs which are not transformed into cock or hens, but grow to be such by the expansion of parts already formed. In the same manner the Tad-pole is not changed into a Frog, but becomes a Frog, by an unfolding and increasing of some of its parts.

Hence it follows, that in the Aurelia, and more particularly in the Nymph, so called by Aristotle* with the greatest propriety, there are not only all the parts and limbs of the little winged animal itself; but, what is more surprisiing, though 'till now unnoticed by any author I have met with, all these parts, or limbs, are to be discovered, and may be shewn in the worm itself, on stripping off its skin in a careful manner. If therefore we retain the name of Nymph, used by Aristotle, the worm at this period may be considered as marriagable, and, if we may make use of these expressions, entering into the connubial state. We may further shew this, by considering that the worms, after the manner of the brides in Holland, shut themselves up for a time, as it were to prepare, and render themselves more amiable, when they are to meet the other sex in the field of Hymen. Since therefore the word Nymph expresses the nature of the thing better than any other, as will more clearly appear hereafter, we shall adopt it on this occasion to avoid confusion, and to be the better understood: for though the words Chrysalis and Aurelia are employed to express the same thing, they properly imply some external differences, which we have already named, and shall hereafter treat of more at large.

That elegant disposition, and distinct framing of parts, which I have mentioned, is particularly observable in the Nymphs of Ants, Tab. XVI. No. v. Flies, Tab. XLI. fig. II, and Bees, Tab. XXV. fig. VI. as will appear upon inspecting their figures in Tab. XVI. XLI. and XXV. For some accidents, as they are

* Hist. Anim. Lib. V. cap. 19.

called,

called, ſuch as colour, firmneſs of the parts, and the like excepted, theſe Nymphs repreſent exactly, and in a ſurpriſing manner, the little winged animals they are to produce; and even in the ſpace of two or three days after they have caſt a very thin ſkin, all thoſe parts appear in moſt of them.

This accurate agreement, or rather this ſameneſs of the Nymph with the little animal it covers in the preſent form, has given room to ſome who have written on this ſubject, to call the Nymphs of Ants, Flies, and Bees, by the names of Ant-ſhaped, Fly-ſhaped, and Bee-ſhaped Nymphs. This we ſee in Ariſtotle, in the place above cited: He ſays, "When they "have received the out lines of the ſhape which "they are afterwards to wear, at this period "they are called Nymphs." Even the learned Mouffet, though in his book of Inſects he beſtows a particular chapter upon the Chryſalis, there denies that any diſtinct parts are to be obſerved in it, yet is not to be underſtood as including the Nymph in that aſſertion; he does not even make the leaſt mention of it: and, indeed, thoſe diſtinct parts are ſo evident in the Nymphs of inſects, as ſcarce to leave the leaſt room in any to doubt, but that they are the very animal which they ſo evidently repreſent. This certainly muſt be the reaſon why the Nymphs are often call'd Chryſallides and Aureliæ by the ſame author, in the courſe of his work; though no deſcription is given of them in the chapter we have here named.

As errors never are confined to thoſe who firſt fall into them, the incomparable Harvey *, by committing the ſame miſtake with Mouffet in his notions concerning the nature of the Chryſalis, has ranked the Nymphs of the Bees in the number of them. With the ſame Mouffet, Ariſtotle and Aldrovandus have explained the difficulties which occur in following, by a nice examination, the tranſmutations of this claſs of inſects, by a ſyſtem more ingenious and ſubtil, than agreeable to truth and the nature of things; ſince both he and Ariſtotle †, Aldrovandus, and numbers of other authors, have imagined, that the Nymphs of Bees are ſo far from containing the parts of the future inſects; that they can only be looked upon as the eggs which are to produce them.

Tho' there are ſome ſlight external differences between the Nymph and Chryſalis, which we have already obſerved, the Chryſalis notwithſtanding ought to be conſidered as a Nymph; there are alſo ſome external differences amongſt the Nymphs themſelves, which it is likewiſe proper to take notice of in this place. Thus, there is by far a greater agreement between the Nymph of the common Ant and the Ant itſelf, than there is between the Nymphs of Bees, or of Flies, and theſe winged inſects reſpectively; ſo that there appears the ſame diſagreement between Nymphs of one kind and another, as between theſe and Chryſallides. But as all theſe differences are merely accidental, as will hereafter more plainly appear, little regard is to be paid to them; notwithſtanding Ariſtotle, who at the ſame time that he aſſerts a ſimilitude, in point of ſhape, between the Nymphs and the little animals to be expected from them, ſo far denies ſuch a property in the Chryſallides, that he repreſents them merely as the eggs of thoſe inſects to which they belong ‡.

That we may treat more accurately of the Chryſalis, or Aurelia, which is indeed nothing more than a gold-coloured or gilded Nymph, and neither is nor ought to be called ſpecifically or diſtinctly by this name, nor can at all times, ſeeing all the Nymphs which are called Chryſallides have not this bright outſide; this Chryſallis, I ſay, in the ſame manner as has been ſhewn of the nymph, "not only contains all "the parts of the future animal, but is indeed that animal itſelf". This truth, however, is contradicted among the antients by Ariſtotle, and among the moderns by Harvey, and numberleſs other writers. As we have obſerved that the Nymph of the Ant differs from that of the Bee; and this laſt from the Nymph of the Fly; we remarked alſo, that the Nymph generally known by the name of a Chryſalis, differs from all thoſe beforementioned. That this may appear the plainer, for example, in the caſe of the Butterfly's Chryſalis, Tab. XXXV. fig. VI. and VII. it will be proper regularly to demonſtrate, not only the differences by which the Nymphs of the Ant, Bee and Fly may be diſtinguiſhed from one another's, but thoſe variations likewiſe by which the Butterfly's Chryſalis is diſtinguiſhed from theſe Nymphs; and the differences alſo, by which all theſe Nymphs and Chryſallides vary from the inſects they are to produce. By this means we ſhall be enabled to attain a perfect idea of that moſt remarkable property, by which they perfectly agree with each other. This property we affirm to conſiſt in an exact repreſentation of the future animal, and of all its parts.

The firſt property then, by which the Nymph of the Ant, Tab. XVI. No. V. agrees better with the Ant, than the Nymphs of Flies, Bees, or Butterflies, do with thoſe inſects reſpectively, and by which property, of courſe, the Nymph of the Ant differs from the Nymphs of the three other inſects before-mentioned, conſiſts in this; that the common Ant, which has no wings, but only antennæ, or horns, and legs, affords as clear and diſtinct a repreſentation of thoſe parts, when hid under the form of a Nymph, as when it afterwards appears in its own proper and perfect ſhape; excepting only, that the legs and horns, which in the Nymph are folded up in a delicate manner, ſhew themſelves at large, and in another ſituation, in the Ant itſelf. So that the different diſpoſition of theſe parts, in the ant and its Nymph, which every one muſt allow to be an article of little conſequence, conſtitutes all the difference that there is between them. Nevertheleſs, the overlooking of this truth, the moſt important of all in the theory of inſects, in the caſe of their Chryſallides, has been the great reaſon why the true knowledge of the nature of this ſpecies of Nymph has been buried to this time in obſcurity, to give way to a fancied metamorphoſis.

* In Lib. Gener. Anim. Exerc. 1.

† In Lib. ii. Cap. 5. de Chryſallide.

‡ Hiſt. An. Lib. v. Cap. 19.

The other difference, or that which is remarkable in ſhape between the Fly, Tab. XLI. fig. II. and its Nymph, and between the other inſects already mentioned, and theirs, conſiſts chiefly in this, that the wings which in the common, or more ſcarce Fly, appear ſtretched out and expanded over the body, are folded up in the Nymph, and lie cloſe along its ſides, and between its legs. This is alſo the caſe in the common Ant; whereas both in the Fly and its Nymph, the horns, and proboſcis or trunk, are almoſt the ſame in every reſpect.

The third difference, or that which is obſerved between the Bee and its Nymph, Tab. XXV. fig. VI. and the inſects already named, and their Nymphs, is this, that the legs and Nymph of the Bee, which, beſides horns, has four wings, and a little trunk turned up towards its body, carries thoſe parts in a different poſition, from that wherein they are ſeen in the Bee itſelf, and in a manner which makes it difficult to diſcern them. The wings, like thoſe of the common Fly, Tab. XXXVIII. fig. IV. are folded up, and lie cloſe along its ſides, and between its legs; but the little trunk, ſo difficult to be obſerved in the common Fly and its Nymph, is very conſpicuous in that of the Bee, where it lies delicately diſpoſed between the contracted legs of the embryo.

As therefore all the parts of theſe Nymphs may be eaſily diſtinguiſhed in them, though occaſionally with ſome accidental differences; ſo one thing is equally common to all of them, namely, that each of them clearly expreſſes the inſect which is to be expected from it, or is rather already that very inſect; which in the manner of the Caterpillar, the better to explain the difference between the Nymph and the future inſect, is now preparing to caſt off a ſkin, to become from a Nymph, a winged animal; in the ſame manner as it had caſt one off before, from a Worm, to become a Nymph. Theſe operations of nature Libavius * has ſufficiently explained in the Silk Worm, and faithfully repreſented in his elegant drawings.

It is, moreover, worthy to be obſerved, that the legs, wings, trunk, horns, and every other part of the animal, are covered with a membrane of equal thickneſs, in every place where they do not lie upon each other. This is the reaſon why, in the Nymphs of inſects, almoſt all the members appear free, flexible, and capable of motion; for there is a ſpace between all theſe parts acceſſible to the air; and they neither touch, nor can adhere to one another. This alſo is the reaſon, why the free ſpace produces a ſlight ſhade between ſome of the parts, affording the curious eye an opportunity of determining exactly the figure of the inſect's little body, and all its limbs; to this cauſe alſo, we are to attribute, that the Nymphs become of a particular colour, as ſoon as they have gone through their neceſſary change, and appear of a perfect milky whiteneſs.

In the Chryſallides, ſome of which, like the other Nymphs, aſſume this milky hue at the time of their change, but afterwards become ſpotted with gold, or entirely cloathed in that rich colour, it is a more difficult matter, on a bare ſurvey of their outſides, to diſtinguiſh the parts of the inſect one from another. Their legs, wings, and the reſt are folded up, and as it were packed together in a moſt intricate manner: and this difficulty has been the cauſe, as will be hereafter ſhewn, of the principal miſtakes of writers on this ſubject.

It is likewiſe worthy to be obſerved, that the Nymphs of all the three inſects we have here taken notice of, the Ant, the Fly, and the Bee, immediately after their change become tender and flexible, and indeed fluid, in a manner like water itſelf; ſo that they loſe all their former ſtrength and vigour: this made Gaza, with great reaſon, call them invalids, as the learned Aldrovandus has obſerved, ſince they remain in this condition almoſt to the end of this period of their life. Mouffet ſeems to have taken notice of this ſoftneſs in ſome Chryſallides, the cauſe of which we ſhall explain in its due place, with the neceſſity there is for it. That author's words are, † "When Pliny ſays that "the body of the Chryſalis is hard, I imagine he "means the Caterpillar." The ſkins which are thrown off by the Nymphs here mentioned, are ſo twiſted and folded together, that, without a delicate hand, and a great deal of experience, it is a hard taſk to diſplay them properly; this will appear when we come to relate our obſervations upon Bees, the curioſity of which has a right to command the admiration of mankind.

We now proceed to the fourth difference, or that which belongs peculiarly to the Chryſalis, and, like the reſt, is only accidental, though a great deal more remarkable. That the reader may know what Chryſalis we are about to compare with its Butterfly, and afterwards with the Nymphs of the Ant, and the Fly and the Bee, and, laſtly, with theſe inſects themſelves; we are to inform him, that we ſhall take for our preſent example that Chryſalis, of which Mouffet ‡ gives a drawing in number XII of his diurnal Butterflies, which is the ſame with that deſcribed by Goedaert, in the twenty-firſt experiment of his firſt part, and which I have repreſented ſeveral ways in Tab. XXXV of this work.

The difference between this Butterfly and its Chryſalis, as well as between the other Nymphs heretofore mentioned, and their animacules, is as follows. The wings, which in the Butterfly ariſe from the ſhoulders, are very large, and hang over the back of its body, in the Chryſalis, Tab. XXV. fig. VII. are gathered up and folded into the ſhape and ſize of half the nail of a man's little finger, and are turned in towards the belly, againſt which they lie of an equal thickneſs, *m m*.

* Obſ. Hiſt. Bomb L. I. C. 21. † Inſ. Th. L. II. C. 36. de Aurel. ‡ Inſ. Th. L. I. C. 14.

The trunk, which in the Butterfly is contracted and curled up into the ſize and ſhape of the head of a ſmall pin, and lies between its wings, appears in the Chryſalis beautifully expanded along its belly, between the two wings *d d*. In the Chryſalis alſo, the legs, *f f*, *g g*, by a moſt inimitable contrivance, the cauſe of which, with the reaſons for it, we ſhall hereafter deliver in our ſelect experiments, which are placed on both ſides cloſe to the trunk, quite otherwiſe than in the Butterfly; and finally, to compleat this ſcene of wonders, the horns, *i i*, which in the Butterfly are ſtretched out at full length over the eyes, lie over the legs in the Chryſalis; ſo that upon the whole, all the parts of the inſect, the body, wings, horns, legs, and trunk, are to be found as well in the Chryſalis, as in the Nymph, in the former, indeed, the feet are leſs diſcernable than in the latter; but the ſame difference is equally obſervable in the reſpective inſects.

The ſkin which contains the Chryſalis, is much thicker in thoſe parts which cover the limbs on the outſide, than in thoſe which ſerve only to keep them aſunder; beſides, all theſe parts are ſo evenly and elegantly faſtened as it were to and upon one another, that they exhibit an uniform and equable contiguity of parts. For this reaſon they are, with the greateſt difficulty, to be diſtinguiſhed from one another, and that only by a ſingular method, which I ſhall explain to the reader in its proper place. This difficulty not only prevented Mouffet from giving us an accurate repreſentation of the Chryſalis in the place juſt cited *, but induced him to deny, with Ariſtotle, that there are any parts in the Chryſalis diſcernable by our ſenſes. He ſays, "the Chryſalis has neither mouth, nor any other part of the ſucceeding inſect, that can be perceived."

Libavius, is under as great a miſtake on this ſubject †; for, though in treating of the Necydalis, he allows it ſome traces of wings, and alſo of horns, he denies that any diſtinct limbs are obſervable in it; his words are theſe, "On the fore part there are marks of legs and horns; and on the back part, towards the ſides, ſome faint repreſentations of wings." But a little afterwards he ſays, "You cannot perceive any diſtinct limbs."

Goedaert is as much at a loſs as theſe authors, about the true nature of the Chryſalis. He is at great pains to make out in it ſome reſemblance of the human face; and he gives a drawing of it, under this idea, in his figures of chryſallides. He ſhould rather have given us that elegant form, which really appears in the Chryſalis, than have endeavoured to amuſe his reader with idle ſpeculations, the more productions of his own fancy. Nor is this all his error; he gives us an unnatural repreſentation of the caterpillar itſelf, in the place already cited; for that Caterpillar is not covered with hair, but with little prickles, and is very nearly of the figure repreſented in his 26th experiment.

As the limbs of the Chryſalis, faſtened together in the manner already mentioned, harden by degrees, or its ſkin, which at firſt was ſoft and tender, gradually dries up, and becomes, as it were, of a horny ſubſtance, it gradually alſo changes the greeniſh hue which it had before, for a gold colour, and all the parts loſe their motion; till at laſt this Chryſalis, or properly the Butterfly, which has lain its time under the form of this Chryſalis, caſting off its hardened ſkin, breaks forth in the very ſhape in which it lay hid under it, without having ſuffered any change during its confinement, unleſs this, that its tender parts, which were fluid like water, and immoveable, through an exceſs of humidity, have with time acquired firmneſs and ſtrength; juſt as it happens in the Nymphs already deſcribed.

When the Chryſalis has caſt off its ſkin, the wings viſibly expand to their true dimenſions in a moſt ſurpriſing manner; and the legs and other limbs unfold themſelves, and aſſume the direction and form we ſee in the Butterfly ‡.

This expanſion of the wings being very ſudden, and therefore difficult to be juſtly obſerved, or underſtood as it deſerves, unleſs by perſons accuſtomed to experiments of this kind; it is no wonder that the moſt happy geniuſes, the immortal Harvey, for example, and numberleſs others, ſhould have fallen into an error on the occaſion, affirming that this metamorphoſis is not external, or occaſioned by any growth in the wings of the Chryſalis; but that it is altogether internal, not only in regard to the wings, but to all the other limbs; inſomuch that Harvey takes upon him to ſay, that the Chryſalis aſſumes a new form in every reſpect, and therefore calls it a perfect egg. The truth is, this ſuppoſed transformation does not take place either internally or externally in the Chryſalis; this is proved by the moſt careful experiments, with which his doctrine totally diſagrees. Nor does he ſucceed better in explaining, than he had, in imagining this metamorphoſis, which by his denying any growth of the parts, and ſubſtituting an imagination of his own, becomes utterly incomprehenſible. Theſe remarks are to be conſidered here as occaſionally introduced; for as we intend to deſcribe in our ſelect experiments, the manner in which theſe wings and the other limbs grow, and to demonſtrate alſo what changes happen from day to day in the egg and Chryſalis of the inſect, both of which we have found to be of the ſame nature, till the Caterpillar iſſues from the former, and the Butterfly from the latter, we ſhall at preſent enter no further on this ſubject.

* Inſ. Th. L. II. Cap. 36. de Aurel.

† Obſ. Hiſt. Bomb. L. I. Cap. 21.

‡ The time in which a Butterfly remains in the Chryſalis ſtate, is not limited by nature to any particular period, but depends on external accidents. Reaumur fancied that he could keep the Chryſalis entire many months beyond the uſual time of the diſcloſure of the inſect, and thus add to the length of the creature's life, though in a condition wherein it had little enjoyment.

Let

Let any one attentively confider thefe accidental differences, by which the Nymphs of infects differ amongft themfelves; the Chryfalis from its Butterfly, and the other Nymphs from their refpective infects heretofore mentioned; as alfo, thofe qualities by which the Nymphs agree both with their animalcules, and amongft themfelves; and he will plainly perceive, that the Nymph and Chryfalis do not differ in the leaft in this nature, or as to the interior conftitution of their parts, fince both diftinctly and exactly reprefent the form of the infect, which is to be expected from them. We allow this reprefentation to be more diftinct and obfervable in the Nymph, than in the Chryfalis; but even this depends in a great meafure upon the good fight and dexterity of the obferver. An indefatigable examiner muft at laft reach the deepeft myfteries of this fcience; and thus an affiduous application has rendered it familiar to me to exhibit, in every fpecies of Chryfalis, all the parts of the fucceeding infect. But, left any oppofer fhould take it into his thoughts to object with the great Harvey, that there is in this cafe a perfect egg, which time may transform, and to which it may give limbs, we can anfwer, that we can perform this operation equally at different times, in the very inftant of the change, or in the beginning, as eafily as in the middle and end of it; and even on the very Worm, before it becomes a Chryfalis. There is no kind of Chryfalis, (however ftrange, unnatural and ludicrous the the figures may be, which Goedaert and others have found out for them, in the wild fallies of their imaginations) in which we are not able to demonftrate all the parts of the future infect; and this as evidently, as in the true Nymph. It appears therefore to be beyond all doubt, that the Chryfalis differs from the Nymph only in colour, and the difpofition of its parts, or, as the philofophers term it, *per accidens*.

But it will be asked, perhaps, how it happens that limbs fhould be more confpicuous in the Nymph, which is evidently the very infect itfelf, than in the Chryfalis, though equally worthy of that name? and why, in the latter, the parts are not fo faftened, as it were, to each other, as in the former. It may be demanded alfo, for what reafon the skins caft by the Nymph fhould be much thinner, than thofe thrown off by the Chryfallides, which part with theirs in the fame manner that the chicken leaves the fhell of its egg. To all this I can only anfwer, that thefe things are hardly, if at all explicable; the nature of them depending entirely on the pleafure of their Creator; and the reafons of this variation being hidden in his impenetrable wifdom, whofe providence has beftowed on his animal productions as great a variety of cloathing, as it has pleafed him to form diftinct fpecies of fuch beings. It appears therefore that in thefe and other as true refearches, we fhould endeavour, by all means, to explain difficulties by reafons drawn from the nature of things themfelves, not from the fcanty ftorehoufe of our imaginations. Otherwife, by deviating though ever fo little from that rule and order, which is firmly eftablifhed throughout the whole creation by the all-wife, and powerful author of it, it is impoffible we fhould not go aftray at every ftep, and lofe ourfelves at laft in the wrong paths, directed by our own feeble and imperfect reafon.

As the foregoing queftions deferve great attention, I fhall propofe that folution of them, which nature herfelf feems to authorize and fupport. We may obferve, that the Nymph of Ants, Flies, and Bees have a much flenderer body than the Chryfalis before fpoken of; and from this it appears reafonable to fuppofe, they fhould have a much tenderer skin. The Nymphs, befides this, are always confined to moift places, where their exterior covering cannot readily harden: do not the Nymphs of Ants lie hid under the earth? and thofe of Flies in putrid flefh, the excrements of animals, and other moift places. As for the Nymphs of Bees, they are always found furrounded with moifture, inclofed in wax, and covered befides, like Silkworms, with a thin membrane: befides this the Nymphs of Bees, at the time when they enter upon their period of change, have all their parts fo exceffively moift, that fometimes they weigh twice as much as the Bees that are produced from them.

It is obfervable, indeed furprifing, that the humours conftituting this moifture muft be diffipated by infenfible perfpiration, before the milky limbs of the infect can move themfelves in the leaft; and all this while the creature difcharges no excrement. This Ariftotle has remarked in exprefs words *.

On the other hand, the Chryfallides of diurnal Butterflies (I fpeak here in general, and do not confine myfelf to one kind of Chryfalis) go through their changes in the open air, with the greateft part of their bodies deftitute of any webb to protect them againft the inclemencies of the weather; for this reafon their outer fkin will naturally grow hard, and therefore may be caft off, as has been already taken notice of, without being liable to fhrink up, or lofe any thing of its original form. Befides, the fkin of the Horned Beetle, Tab. XXVIII. fig. VI, VII, VIII, which is likewife found under the earth, is fo very fine, that in point of thicknefs it is greatly exceeded by the coat of the common Chryfalis.

If any one fhould afk, if it is for the fame reafon that the Chryfalis itfelf grows hard, and the Nymph continues in its former ftate of of foftnefs? and why, on the one hand, the Nymph is covered with a thin fkin, and its limbs adhere but little to each other; whereas, on the other hand, the Chryfalis is furrounded by a kind of hard fhell, and all its

* Hift. Anim. Lib. V. Cap. 19.

parts

parts are in a manner faftened together, fo as to form one fubftance? I muft acknowledge, that I cannot fatisfy his curiofity. For as the Nymphs of Bees, when expofed to the open air, die as foon as it begins to harden their fkin; and on the contrary, the Chryfallides fare no better when confined to a moift fituation; I cannot be brought to think, that things, which are produced by nature every year, in a moft wife, regular, and conftant manner, fhould be left fo dependant upon chance, and the ftate of the air and weather: I willingly grant, however, that it is moifture alone which hinders the Nymphs from growing hard, and that the Chryfallides cannot but harden in an open, airy, and dry fituation. But if, after all, we confider, that the fkin in which the Chryfalis is wrapped up, is not throughout of the fame ftrength, but thicker in thofe parts which are expofed to the air, than in thofe which are out of the reach of its influence, as ferving only to cover the inner furfaces of its members; whereas it is the reverfe in the Nymphs, whofe covering is throughout nearly of the fame thicknefs, and therefore lefs able to protect the enclofed infect from the drying quality of the air; thefe things, I fay, being duly confidered, I cannot by any means allow, that the prefervation of moifture, or the hardening of the Nymphs and Chryfallides, juft taken notice of, depend at all upon chance; unlefs I fhould be fatisfied to give up my reafon fo far as to imagine, that the very being of thefe little animals depends upon chance likewife; and that they fpring fpontaneoufly from corruption; and in this blind manner wilfully doubt of nature's great attention and wifdom, fo confpicuous in her manner of preferving and cloathing this part of the creation. I conclude, from all this, that there is no effential difference between the Nymph and the Chryfalis; and that the variation which appears, confifts only in this, that the fkin of the former is more thin and tender, and that of the latter thicker and harder; to which I may add, that in the Nymph all the parts of the future infect may be eafily feen, whereas in the Chryfalis they are lefs diftinct. That thefe are the principal differences, will appear evidently hereafter, when I treat thofe fubjects feparately, and in a more ample manner.

The manner in which Worms and Caterpillars become Nymphs.

HAVING laid down the fole foundation of all thofe changes which are obfervable in infects, and fhewn that this confifts in nothing but the Nymph, into which, at their proper feafons, all the Worms of flying infects and Caterpillars are changed, or, to fpeak more properly, from which they fhoot out or bud; a change which appears in all, except fuch infects as remain in their eggs, till, without paffing through any intermediate ftate, they have acquired their full vigour, and attained their proper degree of perfection; to which may be added, thofe infects alfo, which, hiding the real fhape of the Nymph under the refemblance of an egg, iffue from it complete animals, as fhall be hereafter explained. Thefe things being proved, it appears neceffary that, before we pafs to the other propofitions, we fhould enter upon and explain the manner in which this change is produced, illuftrating it with the figures of thofe infects that are the fubjects of it.

But as in the forms of thofe infects which fhoot out or bud into Nymphs, there is not only an amazing, but in a manner an infinite variety; and confequently it would be impracticable here to defcribe them all; I fhall particularize only thofe, which differ moft remarkably from each other, and confider them as they have, or have not legs.

We obferve, that of thofe infects which become Nymphs or Chryfallides, fome have no legs, Tab. XVI. fig. II. fome have fix, Tab. XXVII. fig. V. and others a greater number, Tab. XXXIV. fig. II. and Tab. XLIV. fig. III. And as this difference between the various fpecies of infects is particularly remarkable, if we compare them together; fo there occurs a no lefs obvious difference on account of the various number of legs in thofe we have ranked under the third fpecies, viz. that of infects which have more than fix: but in thefe many feeted infects, the fix foremoft deferve our chief attention, as does in the infects that have no legs, that part of their body, which in other animals is called the cheft.

That it may appear upon what grounds we have adopted this method of claffing infects, according to their having or not having legs, and according to their having fix or more, it will be very proper to obferve, that in thofe Worms which have no legs, that part of them, which we have called their cheft, never undergoes any change, or alters its fituation; and that in the Worms and Caterpillars which have legs, be the number more or lefs, the fix foremoft never come off, or change their places in any fenfible manner; Goedaert, in direct oppofition to truth, would have us believe they do, but experiments fhew the contrary. In moft Worms and Caterpillars, not to fay in all, the fix foremoft legs are conftantly preferved by the infect, and that without the leaft change in their pofition: and what is yet more furprifing, in feveral Worms which have fix legs, the alteration in their legs is fo fmall at the time that they fhoot out into Nymphs, Tab. XX. fig. V. that it cannot by any means be diftinguifhed or obferved, whatever metamorphofes the former naturalifts, without any exception that I know of, have idly and extravagantly imagined on this occafion.

As

As therefore the experiments we have made, have, like the rifing fun, diffipated this thick and dark cloud of imaginary metamorphofes, the whole truth thereby appearing in the cleareft and moft evident light; in the fame manner, by purfuing the fame caufe, with that readinefs and confidence which fuch guidances deferve, we fhall readily underftand the moft obfcure and difficult changes which happen in thofe infects that have no legs. As we have refolved in this work not to depend upon inductions of one thing from another to prove the affertions, we fhall abide firmly to the chain of our experiments, and, in confequence of this method, advance, that the wings, horns, and other parts which Worms without legs feem to acquire about their chefts, at the time of their mutation, are not truly produced, during the period of mutation, or, to fpeak more agreeably to truth, during the time of the limbs fhooting or budding out; but that they have grown there by degrees under the fkin, and as the Worm itfelf has grown by a kind of accretion of parts, and will make their appearance in it upon breaking the skin on its head or its back, and thereby give it the figure of a Nymph, which it would afterwards of itfelf affume, Tab. XXV. fig. v.

Hence it is, that we can with little trouble produce the legs, wings, horns, and other parts of an infect, which lie hid under its skin while in the fhape of a naked worm, which has neither legs nor any other limbs. This we have fhewn in the prefence of the celebrated Mr. Thevenot, a gentleman whofe unufual fagacity, in every branch of polite learning, is above praife. We had the good fortune of changing before him the Worm of a Bee into a Nymph, by breaking the skin upon its head, upon which all the parts hid under it made their appearance; and we fince have had equal fuccefs in demonftrating to the fame gentleman, and the illuftrious Lawrence Magellotti, a curious fearcher into the fecrets of nature, all the parts of the Butterfly clearly and diftinctly in the original Caterpillar. We have fince difcovered alfo a method of changing, at pleafure, the Caterpillar into a Chryfalis.

To comprehend in a few words the reafons, foundation, and manner of thefe natural changes, and at the fame time to illuftrate them by a palpable fimilitude, I need only briefly remark, that " the Nymph or Chryfalis" (I here fpeak only of infects without legs, the change that happens in the reft, being, as will hereafter appear, fo eafily underftood as to require no explication) " is nothing more than a little " Worm, which, the growth of legs, wings, " and other limbs hid under its skin being " perfected by time, at laft burfts that skin, " and cafting it off, gives us a clear and dif- " tinct view of all thofe parts." This change, which has been prepofteroufly called a transformation, or metamorphofis, and by fome a death and refurrection, is no more myfterious or furprifing, than what happens, when " one " of the meaneft plants, defpifed and trodden " under foot, gradually fwells on every fide; " and after producing a bud, by burfting the " little cafe containing it, prefents an elegant " and beautiful flower."

We might likewife compare, in this place, the fanguiferous animals with infects; as in refpect to the accretion of their limbs there is not the leaft difference to be found between thefe large creatures, and the little worm we have compared with vegetable fubftances: but amongft all the animals of that tribe, none agree fo exactly or obvioufly in thefe changes with the infect tribe, as Frogs. Thefe creatures are changed into a true Nymph, known by the name of a Tadpole; as will more fully appear hereafter, in the explanation of our plates, and in comparing together the Tadpole, the Nymphs of Worms, and the little cafe in which flowers are produced, Tab. XLVI.

The fame changes therefore, which we obferve in vegetative animals, are equally obfervable in fenfitive ones, fo as to afford us in all God's works the moft manifeft proofs of his infinite wifdom and power, which man can neither imitate nor comprehend: for as the foundations of all created beings are few and fimple, fo the agreement between them is moft furprifingly regular and harmonious, every thing confpiring equally to fill us with fentiments of admiration and reverence for the great Author of nature.

The ferious confideration of the preceding truths, will fet in a juft light the great error of thofe, who, from thefe natural and intelligible changes in bodies, have endeavoured to explain the refurrection of the dead; whereas that great operation not only far furpaffes the powers which we fee in nature, but has not any thing in common with the natural changes of which we have been fpeaking: the refurrection is a fubject of faith only, which gives a certain and undoubted knowledge of things beyond the reach of our fenfes. Thefe animalcules do not die, as man does, in order to rife again; all that happens to them is, that their limbs become improveable at the time of their tranfmutation, which, however, happens in fo furprifing a manner, that it is no wonder obfervers, at firft fight, fhould take the production to be a real refurrection from a dead animal. This is all that can be offered from what we know of infects, in proof of the refurrection of the dead; which is altogether another thing, than that idle and imaginary death of thofe animalcules, or the transformation, as it is called, of their limbs. Nor are thofe authors lefs miftaken, who, from thefe natural changes, which they idly call metamorphofes, have endeavoured to afcertain the transformation of metals; as amongft others, the moft learned Sir Theodore Mayerne has not feared to advance this abfurd notion in the dedicatory epiftle prefixed to Mouffet's treatife on infects. His words are: " Moreover, if

" animals are tranfmuted, why may not me-
" tals be tranfmutable?"

To finifh this inquiry, as it is much more eafy to comprehend the change of the fix-legged Worms, than that of the Worms without legs, of which we have hitherto been fpeaking; feeing the former only acquire wings, Tab. XLV. fig. XXIV, XXV. and its limbs are feen to fhoot or bud out, in the fame clear, diftinct, and gradual manner with the correfponding parts of plants and flowers, fo as to agree more perfectly with fuch vegetation, and with the change fpoken of in Frogs; than what happens in the Worm without legs; fo it cannot but appear furprifing, that men of the greateft fenfe, learning and experience, who have at all times been indefatigable in obferving thefe changes, fhould have fo long continued under a miftake, in regard to the true manner in which they are performed; fubftituting all along, to a fimple but elegant fcene of wonders, the wild flights of their unnatural fancies. Hence it is, that the doctrine of infects remains to this day buried in the profoundeft obfcurity, fo as that not only thofe look upon it as a myftery, who have few opportunities of being acquainted with fuch fubjects, but even thofe alfo who have made this ftudy their regular employment, and were the beft qualified to purfue it with fuccefs, fuch as Aldrovandus, Mouffet, Libavius, and Goedaert; indeed, I might fay all who have hitherto applied themfelves this way, have been fo far deceived as not only to doubt and waver in their opinions; but influenced by prejudices obftinately to remain infenfible to the ftrongeft conviction, that the moft obvious and convincing experiments could afford.

C H A P. III.

The manner in which the true knowledge of the Nymph, the real foundation of all the natural changes obfervable in infects, has been obfcured and corrupted; with an illuftration of the fubject, and an entire reftitution of its original truth.

HAVING manifeftly proved in the preceding pages, that the Nymph, or Chryfalis, is nothing but the very infect which may one day be expected from it; and having proved beyond contradiction, that the former lies hid within the worm, or its fkin, in the fame manner as the tender and growing flower is wrapped up in its bud; fo that as the flower breaks from the furrounding cup, the limbs of the enclofed infect, by the power which fwells and fhoots them forth, muft, in the fame manner, at laft burft their prifon, and make their appearance, which appearance alone conftitutes the nature of the Nymph, or the knowledge of the foundation upon which all thofe natural mutations depend. All thefe things, I fay, having been abundantly demonftrated, I can have no pleafure in giving a long and pompous catalogue of thofe authors, who have entertained different opinions of the matter, nor in refuting thofe ftrange fancies with which they have obfcured and perplexed this moft valuable branch of natural hiftory. Befides, what purpofe could fuch a difcuffion ferve, but to lead us ftill further from the conclufion of this our fecond propofition, fince the fimple explanation of truth, is the beft method of oppofing and overturning falfhood?

However, as Mouffet's elaborate performance on this fubject, is in a manner univerfally read by thofe who ftudy the nature and the changes of infects, and is not only founded on the experiments of the author himfelf, and of his learned friends Wotton, Gefner, and Penn; but in part extracted alfo from upwards of forty authors, of which the learned Aldrovandus is one; and as the author follows fo fcrupuloufly the rules laid down by Ariftotle, that he fcarce ever deviates from them, it is incumbent upon us to mention what he propofes in his elaborate treatife, where he lays down the changes that occur in the Silkworm, as an example of thofe which happen in all other infects; and gives fuch an account of thofe changes, as neither reafon nor experiment can warrant. His words are thefe: * " It is very
" remarkable that in this metamorphofis which
" is performed by means of an Aurelia, the
" Silkworm's head becomes the Butterfly's
" tail; and the head of this laft the tail of
" the former; and the fame thing happens in
" all the other Caterpillars that become Au-
" reliæ." In another part of the fame † performance, where he treats purpofely of the Chryfalis, he fays as follows: " It has nei-
" ther a mouth, nor any diftinct limb." Now as all thefe notions are directly oppofite to the clear and diftinct obfervations we have made, and already delivered, it would be fpending time to little purpofe to dwell any longer upon them; they have been already fufficiently refuted. We need not be now furprifed that this learned Englifhman, who could be guilty of fo great an error (which fome eminent countrymen of his own have before taken notice of in a performance called, " A catalogue of the plants that grow in the
" neighbourhood of Cambridge,") fhould not have taken the leaft notice of the manner in which fuch fanciful changes are performed, though in the fame chapter he with great reafon affirms, contrary to Ariftotle's opinion, that

* Inf. The. Lib. II. C. 1.

† Inf. The. Lib. II. C. 36.

the

the Chryſalis is not the egg of the Caterpillar. His words are: " To conclude, what is there " here in common between an egg and an " Aurelia? The former has neither life nor " motion, and is diſcharged from another " animal; the latter is not diſcharged by any " animal, but is only changed from one thing " into another." However, though Mouffet denies that the Aurelia is an egg, he has not courage enough to call it an animal; he conſiders it only as a kind of medium, or mean condition, between two animals; or as a third being between the Caterpillar and the Butterfly; ſaying, " It appears nevertheleſs by " what I have already ſaid, that the Aurelia is " not an egg; the truth is, that it is to be " called a kind of tranſmutation, and not a ge- " neration of the Caterpillar into an Aurelia, " and of the aurelia into a Butterfly." But as this difficulty, contrived by his own imagination, has rendered utterly inexplicable what otherwiſe might be very eaſily explained, he has recourſe, as is uſual in ſuch caſes, to the immenſe power of the Creator, and after this concludes the ſubject in the following words: " I well know how the Ariſtotlians perplex " themſelves in this caſe with a wonderful " transformation, and at laſt are obliged to " refer us to God's indeterminate power."

But we leave to the wildneſs of their own genius, thoſe learned men, who raſhly affirm that the true notions of every thing that appear in inſects, as well as in other bodies, are to be found in the eminent writers of antiquity. Nature, that indulgent parent, exhibits, all that relates to them, to us, every ſummer, in the plaineſt and ſimpleſt manner; nay, ſhe gives us an opportunity of demonſtrating thoſe her proceedings, and that in the moſt ſatisfactory manner, in the very depth of winter, by the help of the artificial heat of a ſtove, or any like continuance. Let us rather take a ſpecimen or two of the unworthy manner, by which the genuine repreſentations of theſe changes, which are no more than the natural ſhootings of the limbs, that at laſt thereby come to make their appearance, have been confounded and obſcured, even by men who have ſpent their whole lives in reſearches into the nature of animal generation in general; and have applied themſelves more particularly to find out the nature of thoſe changes obſervable in inſects.

The firſt I ſhall mention, is that ſecond Democritus, the celebrated Harvey, who, againſt the current of the moſt convincing experiments, boldly affirms with Ariſtotle, that the Chryſalis (though it be indeed the very inſect) is a perfect egg, from which of courſe the inſect may, by the help of transformation, be afterwards expected to ſpring. Take his own words: * " Such are likewiſe the ſeeds of " many inſects, (called worms by Ariſtotle) " which being at firſt produced in an imperfect " ſtate, ſearch out their food; by which being " nouriſhed and increaſed, from a Caterpillar " they become an Aurelia, and a perfect egg " and feed from an imperfect one." By this, he not only with Ariſtotle calls the Chryſalis a perfect egg, which, according to the ſame author, is neither a Caterpillar nor a Butterfly, but ſeems to give into Mouffet's falſe and abſurd opinion, who affirms, that the Chryſalis is a kind of medium, or middle being between the Caterpillar and the Butterfly. This paſſage of Harvey's ſhews us, that he was not acquainted with thoſe inſects which proceed immediately from an egg in a ſtate of perfection, without ever appearing in the form of worms, Caterpillars, or Nymphs; or at leaſt that he imagined the mutation they undergo is performed within the egg; and that therefore their generation is the ſame in all reſpects with that which he has deſcribed as proper to Chickens within the egg of the Hen; or with that other generation which he attributes to the worms of inſects †, which ſpring from eggs, and which he repreſents as perfectly agreeing with the generation of Chickens.

But although this great philoſopher calls the Chryſalis a perfect egg, he nevertheleſs does not aſſert that the inſect proceeds from the chryſalis, as from an internal and hidden principle, in the ſame manner that he affirms the chicken ſprings from the Hen's egg, or that the inſect is formed by one part of egg, while it only receives the matter of its increaſe from the other part; which he ſays is the caſe in the generation of Chickens. Nay, his opinion on this occaſion is far more rational and ſolid, for he admits it, with Ariſtotle, as an axiom: ‡ " That the animal is not made out of the " worm, as out of an egg, from a part of it; " but that the whole worm grows, and be- " comes an articulated animal," without conſidering that Ariſtotle calls the Aurelia an egg. Now if we compare the paſſage which Harvey has adopted from him, with the ſcene which nature every year preſents to us, we ſhall find the words contain a true definition of the Nymph: but as both Harvey § and Ariſtotle ** have here beſides fancied a metamorphoſis, which they call " a diſtribution of one thing " that is to be altered into many;" and which in another place †† Harvey has expreſſed by the following periphraſis: " In the generation " that is performed by a metamorphoſis, things " are produced as it were by the impreſſion " of a ſeal, upon the matter of them, or by " this matter's being caſt into a mould, the " whole of it entirely transformed." This account is not only falſe, but altogether degrades and darkens the true ſyſtem of thoſe natural mutations: no ſatisfactory explication can be drawn from it, of any manner in which theſe fancied metamorphoſes, and imaginary transformations, can be ſaid to happen.

But the better to underſtand Harvey's doctrine of inſects, which, however, does not

* Lib. de Gen. Anim. Exerc. II.
† Lib. de Gen. Anim. Exerc. LVII.
‡ Lib. de Gen. Anim. Exerc. XVIII.
§ Exerc. LXXII. de Hum. Primig.
** Lib. II. de Gen. Anim. C. 1.
†† Exerc. XIV. de Gen. Anim.

reach

reach the outer limits of this branch of natural hiſtory; and at the ſame time, to ſhew what egregious miſtakes we are apt to commit, the moment we abandon the ſolid arguments furniſhed by experiments, to follow the falſe lights ſtruck out by our weak and imperfect reaſon, I ſhall here give his imaginary account of this matter, as I find it in his book upon this ſubject *, in his own terms,

" There are two ways," ſays he, " in which " we obſerve one thing to be made out of " another (as out of matter) both in art and " in nature, eſpecially in the generation of " animals; one is, when a thing is made " out of another, already in being, as a bed " out of wood, and a ſtatue out of ſtone; " when, for example, all the ſubject-matter " of the workmanſhip exiſts, before the work- " man begins the work, or attempts to give " give it any form. The other way is, when " the ſtuff receives both being and form " at the ſame time. As therefore the works " of art are performed two ways; the one " by the workman's dividing, cutting and par- " ing away the matter prepared for thoſe ope- " rations, ſo as to leave behind, like a ſtatuary, " the figure of the thing he intends to make: " the other, by the workman's adding and " moulding, as well as paring away, the mate- " rials, and at the ſame time tempering the " matter itſelf, ſo as to produce. like a potter, " the figure; which, for this reaſon, may be " ſaid to be made, rather than formed. In the " ſame manner it happens in the generation " of animals; ſome of which are formed and " and transfigured out of matter already di- " geſted and encreaſed for this purpoſe, all the " parts ſpringing out together diſtinctly, by a " kind of metamorphoſis; and thus forming a " perfect animal, while other animals are made " piece by piece, at firſt deficient both as to " ſize and ſhape, afterwards receive both by " degrees, from the ſame matter out of which " they were originally formed. In theſe laſt " animals, one part is made firſt, and the other " parts, by means of this firſt, as the princi- " ple of the animal's exiſtence. This proceſs " of nature, we call an epigeneſis, or accretion " of parts, on account of her forming the parts " gradually one after another; and this is more " properly called generation than the other.

" The generation of inſects is performed " after the firſt manner:" when the worm, by a metamorphoſis, proceeds from the egg; or the rudiments are formed out of matter in a ſtate of putrefaction (by growing too dry or too moiſt) " and theſe rudiments produce, as " by a metamorphoſis, a Caterpillar grown to " its full ſize, or an Aurelia, a Butterfly or " a common Fly of its full ſize, ſo as never to " grow bigger. But the more perfect ſangui- " ferous animals are formed by an epigeneſis, " or a ſuperaddition of parts; and after their " birth, grow to a ſtate of adoleſcence, and " arrive at their perfection. Chance or for- " tune ſeems chiefly to pride in the production " of thoſe animals, which owe their form to " the power of a pre-exiſtent matter; which " matter is the firſt cauſe of their generation, " rather than any external efficient; for which " reaſon thoſe animals are more imperfect, " and perpetuate themſelves leſs, both as to " number and likeneſs, than ſanguiferous land " or water animals; which, by deriving their " being from an univocal principle, (that is, " from other animals of the ſame kind) keep " up an eternal ſucceſſion; and the cauſe of " of this we attribute to nature, and a vegi- " tative power.

" Some animals, therefore, are produced of " themſelves from matter digeſted ſpontane- " ouſly, or by mere chance, as Ariſtotle ſeems " to advance in the VIIth book of his metaphy- " ſicks, chap. 9. Thoſe animals, to wit, " whoſe original matter can give itſelf motion, " ſuch a motion, by accident, as the ſeed gives " itſelf in the generation of other animals. And " the ſame thing happens in the generation of " animals, that is obſervable in the works of " art; for ſome things which are produced " by art, are likewiſe brought about by acci- " dent, as health; other things that are made by " art, are never made otherwiſe, as a houſe.

" Bees, Waſps, Hornets, or Butterflies, and " whatever other animals are generated by " metamorphoſis from a creeping inſect, are " ſaid to be the offspring of chance, and there- " fore never to keep up their ſpecies. But the " Lion or Cock are never produced ſpontane- " ouſly or by chance, but are the work of " nature; wherefore they do not require a " ſuitable matter, or ſome other divine power, " ſo much as a ſimilar form.

" In the generation by metamorphoſis, ani- " mals are faſhioned as it were by the im- " preſſion of a ſeal, or framed in a curious " mould, all the matter of which they conſiſt " being transformed; whereas the animal which " is produced by way of epigeneſis, or accre- " tion, at once attracts, prepares, digeſts, and " makes uſe of the ready matter; it at once " grows and acquires its form. In the former, " the plaſtic power divides the ſame ſimilar " matter, arranges it when divided, and re- " duces it into limbs; from ſimilar making it " diſſimilar, or forming diſſimilar organs with " a ſimilar ſubſtance. But in the latter, whilſt " it produces in order different parts, and thoſe " parts differently diſpoſed, it requires and " makes different ſubſtances; and ſubſtances are " variouſly diſpoſed, the better to ſuit the dif- " ferent parts that are to be generated."

This is the doctrine of Harvey; and this his diſſertation contains almoſt as many errors as words. This may appear ſurpriſing in one ſo well verſed in enquiries of this kind, where truth can only be aſcertained by experiment: notwithſtanding all his errors, we muſt do his great merit in other reſpects juſtice; his diligence in ſtudying nature was very great, and he

* Lib. de Gen. An. Exerc. XLV.

he therefore deſerves not only our praiſes, but thoſe of all mankind; and the candid manner in which he uſually offers his opinions, is yet more praiſe-worthy; for he thus moſt ingenuouſly ſpeaks, in the preface to that performance I have been juſt now mentioning: "Therefore, (generous reader) I do not expect you ſhould take my word as to the manner in which the generation of animals is performed: I appeal to your own eyes as witneſſes and judges of what I advance. For as all perfect ſcience is built upon ſuch principles, as are derived from the obſervations of ſenſe; you ought ſtrenuouſly to endeavour, if you have a mind to become thoroughly acquainted with what relates to animals, to attain this knowledge, by frequent diſſections of them. If you proceed otherwiſe, you can only acquire a ſpecious and wavering opinion, but no certain and ſolid ſcience."

To conclude, it is not our intention to refute one by one, in this place, all this ingenious but miſtaken author's propoſitions; ſeeing this is abundantly done already, by the evident truths we have produced; neither will the dignity of ſo great a name, eaſily admit of ſuch a cenſure, (in abſtaining from which, we only follow the example himſelf has given us in the caſe of that famous anatomiſt Fabricius ab Aquapendento, whom he ſpares in the ſame manner, and on the ſame account.) Nevertheleſs, I cannot avoid again inculcating at leaſt one principle; that whereas the Nymph is indeed the animal itſelf, and by no means the egg, the whole and only mutation which happens here, is nothing more than a ſlow evaporation of the ſuperfluous moiſture; for by this all Nymphs are neceſſarily changed.

Thus it happens, that during this evaporation, before explained in the Nymph of the Bee, the limbs which were before tender, weak, and fluid like water, are freed from the ſuperfluous moiſture which deprived them of motion; whereby the latent inſect is enabled to force its exterior covering, and, having caſt it off as the Bee does, or forſaken it as is done by the Butterfly, to make uſe of the moiſture which remains, to expand its wings and other parts.

The Nymph therefore, during the firſt days of its change, reſembles a man who has loſt the uſe of his limbs, by a collection of ſaline or other humours about his joints, and does not recover them, till ſuch hurtful moiſture is diſſipated by nature, or by art. Nature and art have the ſame effect upon tumified members, and upon what we call Nymphs; ſo that on evaporating the ſuperfluous humidity of theſe laſt, by the means of nature, or by an artificial heat, they may be brought forth in the form of inſects, even in the depth of winter.

In fine, as it is utterly erroneous to ſuppoſe, that the whole maſs of the Worm is transformed into the Nymph, and after this the Nymph into a winged land or water animal; ſo, on the other hand, nothing is more certain, than that all the limbs of the Butterfly, the common Fly, and ſuch other inſects, do actually grow in the Worm, in the ſame manner as the limbs of other animals: ſo that nothing can be more repugnant to truth, or be ſo little ſupportable by any ſolid arguments, as this notion of a metamorphoſis: for it is not in the Nymph alone, but in the very Worm, or Caterpillar: Tab. XXXVII. fig. II. III. and IV. we can lay before the eye all the parts of the future inſect. Thoſe parts are by no means generated ſuddenly and all at once, as has been ſuppoſed; but grow leiſurely one after another, till all of them having arrived at a ſtate of perfection, the Worm gives itſelf motion, and breaks its ſkin; the incloſed limbs having generated by degrees, from the motion of the moiſture, and their own contraction, ſwell and eaſily caſts its ſkin, and ſuddenly diſcloſes all its limbs to our view. In this inflation, (ſhooting out, budding, or vegetation; and, as it were, changing of the nutriment of the new limbs, which have gradually grown, or have been produced by an epigeneſis, or accretion of the parts, and not at all by a metamorphoſis) conſiſts the ſole foundation of all the changes which we remark in inſects. We call the creature in the ſtate of this natural mutation a Nymph, becauſe this kind of inſect, on caſting its skin, may be ſaid to reſemble a bride or Nymph, who, in many countries, leiſurely prepares and adorns her perſon for her intended ſpouſe. But we utterly deny what Goedaert has in ſeveral places advanced, that there is any reſemblance between the Nymph and an infant in its ſwathing clothes; as alſo its likeneſs to any other figure than that of the future inſect; for the Nymph not only repreſents clearly and diſtinctly all the parts of the future inſect, but is, in reality, the inſect itſelf; and this, not dead or buried, but, as Libavius has already obſerved of the Necydalis, actually living and feeling, though unable to give any indications of life, except by the motion of its tail or belly; for in many we find theſe parts are not affected with any moiſture, nor undergo any change, but what ariſes from the caſting off a very thin skin, ſo that they cannot loſe their former power to move.

Allowing therefore as a certain truth, as it really is, what has been already advanced in this work concerning inſects, not only all that Harvey ſays upon the ſame ſubject, in the extracts we have given, and all the errors that flow from thence, fall to the ground; but likewiſe that common opinion of philoſophers, that the generation of inſects is fortuitous, and which Goedaert's editors ſeem to have fathered, or rather to have forced upon him, appears utterly groundleſs; ſeeing it has no other foundation, than that idle and imaginary metamorphoſis, which neither exiſts in nature, nor can fairly be deduced from Harvey's (in many places) contradictory arguments. This great man muſt have eaſily ſeen the weakneſs of his own repugnant notions, had he not been too much prejudiced in favour of the opinions which they were calculated to ſupport or explain, if the reſpect we owe him will, after all, permit us to think he really gave into this abſurd notion. Perhaps we may with more juſtice aſſure ourſelves, that he proceeded on this occaſion, in the manner that people generally proceed in conſidering things that are difficult to be underſtood and accounted for; that is, by fancying ſomething, which ſeems, on mature deliberation, beſt to agree with the nature of things, as Ariſtotle had long ſince directed, in his treating of the generation of Bees *; his words are, "That the generation "of Bees is performed in this manner, ſeems "not only agreeable to reaſon, but to what "appears to happen in the generation of other in-"ſects of this kind; however, the obſervations "hitherto made are not ſufficient to give us a cer-"tain knowledge of what it is that really happens. "When we have acquired that certain know-"ledge, we muſt truſt our ſenſes, rather than "our reaſon, by which we are to be guided, "as far only as what it demonſtrates, agrees "with what our ſenſes aſcertain." Daily experience ſhews us, how many and how great errors this method of philoſophiſing hath produced; ſo that an author would do much better to own his ignorance ingenuouſly, than to lead aſtray, by unnatural phantoms, thoſe multitudes of credulous readers, who, idly thinking that all true learning is to be found in books, never give themſelves the trouble of immediately conſulting nature herſelf: perhaps we ought rather to pronounce ſuch idle followers of knowledge well worthy of this puniſhment, for neglecting the opportunities of finding it in the things themſelves with which they are deſirous to be acquainted.

Having ſhewn in ſome meaſure on how uncertain a foundation Harvey's account of the natural mutations of inſects is erected, it remains to conſider with what groſs errors, and palpable falſhoods, Goedaert has defiled them: but at the ſame time we own with ſatisfaction, that this author alone obſerved and diſcovered, in the ſpace of a very few years, more ſingularities in the Caterpillar kind, than had been done by all the learned men who treated the ſame ſubject before him. Notwithſtanding this, we cannot help ſaying, that not only he was not free from miſtakes, but that he has made ſome ſuch important ones, as can ſcarcely, if at all, be excuſed: not to mention his not having had the leaſt notion of the true nature of the Nymph. But as we have reſolved to examine on a ſucceeding occaſion, ſeparately, all the errors of this author, we ſhall produce at preſent only two of the moſt glaring; upon which, as upon a frail and ſlippery foundation of ice, all his experiments are built. Nor ſhall we do this with any other view than that of making truth appear the more ſtrong and plain, by being compared with falſhood; for the more naked truth is propoſed, the more powerful it is to ſubdue errors.

In the firſt place Goedaert is under a very great miſtake, when he advances, that the Caterpillar can be changed, before it has reached the full term of its growth; adding alſo, what is ſtill more apt to lead people aſtray, that the mutation effected in this manner is very incomplete and unnatural. But let us attend to his own words, in the firſt volume of his ſingular obſervations on the wonderful mutations that happen in the Caterpillars, page 12 of the Dutch edition. "I have beſides obſerved," ſays he, "that, whenever the Caterpillars effect "a mutation, before they have been ſufficiently "fed for that purpoſe, and have reached the "full term of their growth, they never receive "a perfect form in conſequence of ſuch pre-"mature change, but are miſhapen and miſe-"rable, with ſhort and ſhrivelled wings, like a "piece of ſcorched parchment; whereas other-"wiſe, in leſs than half an hour, theſe uſeful "parts expand themſelves, and acquire their "proper beauty, with a variety of elegant co-"lours. Hence it happens, that the unhappy "inſect, not being able to make any uſe of "thoſe imperfect wings, is much more mi-"ſerable than it was before its change, being "obliged to creep upon the ground, where it "at laſt periſhes for want of proper nouriſh-ment." Afterwards, in his twenty-eighth experiment, it appears, that on the ſtrength of the foregoing hypotheſis, having for ſeveral days ſupplied a Caterpillar with food, though all the time preparing for its mutation, be breaks out into the following words: "If I omitted giving it "food, but for one day, it immediately ſet "about changing; for which reaſon I took "care not to make it faſt any longer, as ſo "premature a change was likely to produce but "an imperfect Butterfly; for it is remarkable "of all Caterpillars in general, that as ſoon as "they find their food fail, they prepare for a "mutation; but if it fails of its food before "the term appointed by nature, the inſect pro-"duced is both imperfect and tender; ſo that "to have a ſucceſſion of complete Butterflies, "the Caterpillars muſt be provided with food, "till they refuſe it of their own accord, in "order to enter upon the buſineſs of muta-"tion." At length, after having given in the eighth experiment on the ſtrength of a mere conjecture, the example of a nocturnal Butterfly, which was, in his judgment, the weaker, becauſe its Caterpillar had been deprived ſooner than it ought of its ordinary food; in the fifty-ninth experiment of the firſt volume, and afterwards in the thirtieth of the ſecond, he in a manner opens the ſource from which he derived all thoſe his miſtakes; for after deſcribing a very miſerable animal, that was neither a Caterpillar nor a Butterfly, according to the idea he had idly formed of it in his own fancy, he adds, "The reaſon of all this is, that "the Caterpillar had entered upon the buſineſs

* Gen. Anim. Lib. III. C. 10.

of

"of mutation, before it had taken its proper "quantity of nouriſhment." As this argument appeared to him moſt inconteſtible and evident, he afterwards, in the twenty-ninth and thirtieth experiments of his ſecond volume, where he deſcribes ſuch another imperfect animal, and one with wings, does not mention one word of this falſe propoſition, but paſſes it over in ſilence, as if ſufficiently proved, and not liable to contradiction.

Since in the places here cited two animals are exhibited, one of which, namely, the female, is always, by an invariable law of nature, tranſmuted without wings, Tab. XXXIII. fig. VI. whilſt the other, which is the male, never appears without them. No. VI. not only the genuine foundation of all natural mutations is overturned, and rendered obnoxious to chance, by the idle comments which we have extracted from Goedaert, but the road to truth is alſo rendered impracticable, at leaſt to the unſkilful.

Goedaert himſelf could not avoid the conſequences of ſuch raſh and idle fictions; he has thence fallen into two other miſtakes. The firſt is ſeen in the pains he muſt have been at to ſupply his Caterpillars with food as long as they required it. The ſecond, his omitting, on this account, ſome very curious experiments; for, infatuated with his own prejudices, he neglected the true knowledge he might have acquired by his experiments, to adopt a falſe reaſoning; ſo that he could never afterwards by his experiments come to know, that the ſpecies of Caterpillars he deſcribes, are never changed after any other manner; the male Caterpillar becoming conſtantly a tender inſect, furniſhed with wings, and the female a coarſe and big-bellied one without any.

The obſervation made in the place here cited appears to be of the utmoſt importance, viz. "That the male of the nocturnal Butterfly is "is always provided with wings, whereas the "female never has any;" ſo that the male can enjoy the ſweet refreſhments which the free air affords, and ramble at pleaſure over the ſmiling fields and fragrant flowers, when, on the other hand, the care at home, and management of the fruits of wedlock, are committed to the female only; for which reaſon, ſhe is always found with the hinder part of her body thruſt out, in order, as it were, to induce the male to do his duty; nor does the male ſeem indiſpoſed to perpetuate his ſpecies. Nature, therefore, intended to afford us in theſe inſects the moſt ſtriking examples of an affectionate mother, and a careful father; and perhaps, as the ſlothful were formerly refered to the ant, as a pattern of induſtry, married people, that neglect the duties of their ſtate, may, with equal propriety, be deſired to conſider this other little inſect as a model of conjugal ſolicitude.

As it ſufficiently appears from our experiments, which contradict thoſe of Goedaert, (though that very obſervant author has taken the right method in making them, and hath given tolerably accurate figures) what falſe conſequences he has deduced from thence, and, by that means, rendered the ſtrongeſt baſis of the origin of inſects wholly ſubject to chance; we ſhall now reſtore this foundation, whereon, as on a rock, depends the whole fabrick of the tranſmutations of inſects, and ſhall lay down the following as undoubted axioms. Firſt, that the Caterpillar cannot be changed before the time appointed by nature, that is, the laſt moment of its growth. Secondly, that although Caterpillars may be transformed before they leave off feeding, yet this has no effect to cauſe any change in their form. We muſt however acknowledge that ſome difference in ſize may ariſe from hence, which we muſt obſerve hath not been noticed by Goedaert, nor, hitherto, by any other perſon. Wherefore, thirdly, we by no means think it neceſſary that the Caterpillar ſhould be fed until it ceaſes to eat of its own accord; for at the time when it is to undergo a change, the buſineſs of feeding is not only unneceſſary and difficult, but entirely uſeleſs. Conſequently, the concluſions of Goedaert before mentioned, have not been drawn from the nature of things, but from his own falſe and chimerical notions. For he, not having examined his experiments with deliberation and diligence, deceived himſelf and others.

We may take it for granted, that as ſoon as the Caterpillars have arrived at their utmoſt growth, that is, when all the limbs under the ſkin have grown to a proper ſize, they have not only power and ability, but alſo, if I may be allowed the expreſſion, a free and abſolute will to begin their mutation, with this reſtriction only, that they cannot omit or avoid it; ſince the budding limbs, which demand, as it were, to be changed into the Nymph, in proceſs of time, burſts the ſkin, though they can feed for a conſiderable time afterwards: but then, as I have before obſerved, this further feeding is of no other uſe but to make the creature larger or ſmaller, for from that time not even the leaſt of their limbs is increaſed in length. This Harvey hath alſo remarked, in his treatiſe of the generation of animals. From hence it alſo follows, that theſe animalcules, now grown to perfection, attaining the age of maturity, and fit for the copulative ſtate, apply themſelves ſolely to propagating their ſpecies, in the execution whereof ſome particulars are ſo aſtoniſhing, that they deſerve everlaſting admiration.

Nature performs the whole proceſs of generation in theſe inſects in ſo clear and open a manner, that by the aſſiſtance thereof it ſhould ſeem as if we could penetrate into the true foundations (though hitherto buried in darkneſs) of the generation of other animals, which we ſhall evidently demonſtrate, when we have time and opportunity for further experiments.

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That we may give our opinion on this head in a few words, it ſeems very probable, that in the whole nature of things there is no generation that can be properly ſo called, nor can any thing elſe be obſerved in this proceſs, than the continuation, as it were, of the generation already performed, or an increaſe of, or addition to, the limbs, which totally excludes the doctrine of fortuitous propagation. Having eſtabliſhed this principle, it is eaſy to explain the reaſon that a man, deprived of hands and feet, may have a ſound and perfect offspring. Hence, alſo, we may determine that famous queſtion, whether, in order to produce a complete iſſue, a ſeminal particle drawn from every member of the body be abſolutely neceſſary. Moreover, the reaſon is evident, how Levi, being yet in his father's loins, paid tythes long before he was born: for he was in his father's loins, when Melchiſedeck met Abraham. Laſtly, even original ſin (in the opinion of a very learned man, to whom we have occaſionally communicated the myſteries of our experiments) may ſtand on this principle as on a firm foundation, ſince all mankind have been laid up originally in the loins of their firſt parents. But, ſince others claim the right of explaining ſuch myſteries, we ſhall enter no further into this matter, but come to another error of Goedaert, intending to diſcuſs the reſt, when we have occaſion to examine any more of his experiments; for it is not our intention to build on another's foundation.

A further error of Goedaert appears in the 77th experiment of the firſt part, in the words following: " What is more particularly wor-" thy of our notice in theſe inſects is, that " wherever the legs are ſituated in the Cater-" pillar, there is placed the back of the ani-" malcule that is to ariſe by tranſmutation: " and on the contrary, where the back of the " Caterpillar was, there, are the legs in the " animalcule to be produced from thence. " This metamorphoſis, adds he, (which ren-" ders him the more blameable) is per-" formed in a ſhort ſpace of time, ſo that it " may be diſtinctly ſeen; becauſe immediately " after ſhedding its ſkin, this change appears " to the eye." From hence may ariſe a proper opportunity of explaining accurately and carefully the true tranſmutation of the Caterpillar into the Chryſalis; but as this matter is (as far as hitherto is neceſſary to be explained) very evident, from what we have on ſeveral preceeding occaſions ſaid thereon, we ſhall here paſs it over in ſilence; and the rather, becauſe we have determined to treat this matter profeſſedly in the following ſheets; for we ſhall ſhew from reaſon, and illuſtrate by figures, after what manner, and in what place, every limb of the Nymph and Butterfly are diſpoſed and arranged, which we have before actually laid before the eye, in the preſence of Magalloti and Thevenot, by ſhewing all the limbs of the Butterfly in the Caterpillar. Therefore, to prove the falſity of what we have cited out of Goedaert, it is ſufficient only to repeat, that the ſix fore legs of the Caterpillar are never changed or tranſpoſed in any remarkable manner. And though Goedaert thought himſelf ſuperior, with reſpect to the ſharpneſs of his ſight, to Mouffet, Harvey, and others (whoſe thoughts on this ſubject were conjectural) and has aſſerted the contrary to their doctrine, yet nothing is more certain than that not only he, but thoſe who boaſt to have ſeen it, were groſsly deceived. This deception may poſſibly ariſe from two cauſes: the firſt is the ſwift ſhedding of the ſkin; whence it happens, that the limbs, hitherto hidden, ſuddenly appear, and are diſpoſed in a form quite different from what they were in the Worm: the ſecond may be owing to ſome protuberances and ſwellings, which are on the back of the Caterpillar, and, as ſoon as the ſkin is ſhed, have the reſemblance of legs. Indeed, a perſon more quick-ſighted than Goedaert, may be deceived by this, ſince the change of the ſkin happens ſuddenly, and, as it were in the twinkling of an eye: wherefore, even the more modern authors, who wrote moſt accurately on this ſubject, have diſcovered nothing elſe, than that the ſkin is firſt broken on the head and back. This is plain from that very elaborate treatiſe of the generation of theſe inſects, publiſhed by Francis Redus, principal phyſician to the grand duke of Tuſcany, in his own language, in the year 1668; wherein he has proved, by the ſtrongeſt arguments, that no inſects are generated by putrefaction. This doctrine we ſhall not only willingly grant this eminent phyſician, but further we ſcruple not to aſſert, that putrefaction is, in a great meaſure, produced by thoſe very inſects which are ſuppoſed to ariſe from it: but of this matter more at large hereafter.

In order to ſhew the origin of thoſe ſwellings on the back of the Caterpillar which impoſed on Goedaert, as ſo many ſignals of changing their legs, it muſt be obſerved, that many of the Caterpillars, whilſt they are changing, caſt off from thoſe hairs wherewith their bodies were before roughened and briſtly, a very tender, and, as it were, membranous ſheath; after which, the finer part of thoſe hairs appear like ſo many linen threads in the Chryſalis. But ſince this Caterpillar of Goedaert's is covered with hairs which are more like briſtles than linen thread, it follows, thoſe hairs and the reſt of the body having ſhed their ſkin, form in the Chryſalis the figure before mentioned, and appeared as if the legs were tranſpoſed. This is what led Goedaert into another error: for if he had known theſe ſeveral particulars, he might have eaſily inveſtigated the origin of thoſe ſilken yellow threads, which he tells us he ſaw in the Chryſalis, and which are deſcribed in the 20th experiment of the firſt part.

It is not only very certain that the change of the Caterpillar into a Chryſalis may be perceived by the eye, but our experiments proceed ſo fo far, that, by following nature, we are able to produce the Chryfalis from the Caterpillar ftate. Nay, it is in our power to keep back this tranfmutation, or to retard the fame to any degree we think proper, though it happens fo fwiftly and fuddenly, and therefore, undoubted credit ought to be given to the feveral matters we publifh here concerning this change. Hence it is, that we can now exhibit to public view many Chryfallides, reduced to almoft one half; this, among feveral other myfteries of nature, we have fhewn before his ferene highnefs Cofmus the third, grand duke of Tufcany, when he, by a fpecial mark of diftinction, was gracioufly pleafed to vifit us, and to approve of our experiments.

But to have done with the errors of Goedaert, which we have hitherto been fetting right, we fhall lay down the following as undoubted truths. Firft, that the legs of the Caterpillar, or Worm, are never tranfpofed to the back. Secondly, that the Caterpillar is not changed into another animal, though, in procefs of time, the legs themfelves grow in the fame manner, as the wings of a young bird, or feet of a Tadpole. Thirdly, that no natural transformation happens in thefe infects; but that this whole change, (in finding out the nature whereof, authors have committed fo many errors, and proceeded, as it were, blind-fold, like the combatants of old) confifts only in this, that the limbs of the Caterpillar, or Worm, by an accretion of the parts, grow infenfibly under its skin; and when the latter is fhed, the former appear plainly and diftinctly to the fight, but they cannot be moved at firft by the little animal; the reafon of which is, becaufe they are fluid like water, and cannot acquire fufficient ftrength, unlefs they evaporate it for fome days before.

But this does not hold in all Worms, fince there are many which lofe no part of their motion. To render this matter the more clear, we fhall now proceed to the third propofition, defiring the reader to confider it attentively, as it is a matter of the greateft importance, and of very great extent.

CHAP. IV.

Of the four orders of natural changes, to which we refer nearly all the fpecies of infects, as having the fame fole principle of change.

HAVING hitherto, from the nature of things, examined and drawn, as it were, a juft and elegant picture of the true origin of thefe appearances, or, as they may be called, fudden buddings and fhootings into limbs in infects, and by that means, fhewn how this fubject hath been difgraced and obfcured by chimerical notions, and the idle traditions concerning thefe changes; having likewife cleared the fubject from the impurities wherein it was involved, by eftablifhing it on a ftrong and firm foundation, which cannot be fhaken by any force; and in our opinion, can no more be fet afide in favour of fortuitous chance, than a Lamb can be generated by a Wolf, or an Eagle by a Dove, we fhall now proceed to the pofitions themfelves, or to the feveral orders of thefe changes; whereby, as with the genuine tinct of nature, we fhall endeavour to illuftrate the picture before us, and reftore the amazing and wonderful appearances of infects to their true fplendor and native beauty. Thus fhall we more clearly be fenfible of, and, with greater devotion and more humble reverence, meditate on the omnipotent wifdom and fuperlative goodnefs of God in the accretion, fuftenance, and change of the minuteft animalcules, which form a celeftial hoft as the angels.

If we diligently attend to this true bafis of all the changes of infects, that is the Nymph, it will be eafy to comprehend the reafon why all the fpecies, tho' fo many in number, together with their changes, agree and terminate in this one particular; wherefore it feems fuperfluous to dwell longer on the explanation of them. If again we more ferioufly confider after what various ways this Nymph hides itfelf under the manifold forms of thofe infects, fo as to elude the fharpeft eye; it will become neceffary to view this Nymph in every light, under all its accidental appearances. And herein we fhall not follow as a guide the delufive traces of our own ingenuity, or admit the inventions of fancy, but purfue only the various and natural phænomena of the Nymph. There are four orders which comprehend the whole clafs of infects, fo that we cannot fee one, which may not be referred to one or other of them, efpecially if we can fee its change.

The firft order will comprehend thofe infects, which, with all their limbs and parts, proceed inftantly out of the egg, and grow infenfibly, until they attain a proper fize; after which they are changed into the Nymph, which undergoes no other change but that of its skin.

Of the fecond order are thofe hatched with fix legs, and which, when the wings are gradually perfected, are alfo changed into Nymphs.

The third order is, when the Worm or Caterpillar comes forth from the egg either without any legs, or with fix or more, and its limbs afterwards grow under the skin, in a manner imperceptible to our fight, until at length it cafts that skin and refembles the Nymph, or Chryfalis.

The fourth order is, when the Worm likewife proceed from the egg, either without any, or with fix, or more legs, and in an invifible manner grows in its limbs and parts under the skin, and does not fhed this skin, but acquires the form of a Nymph under it.

Having laid down thefe general propofitions, I fhall hereafter diftinctly and at large, defcribe the Nymph under thefe four different orders; and at the fame time fhall lay it before the eye by particular examples, illuftrating every defcription; but in the firft place, I fhall enumerate the infects which belong to each order.

The FIRST ORDER.

Of the natural changes, or flow accretion, of the limbs.

AS on the one hand it appears, from the niceft experiments, that all infects proceed from an egg, that is laid by an infect of the fame fpecies, with whatever warmth fome philofophers have maintained the contrary; fo on the other it muft be obferved, that fome infects iffue therefrom inftantaneoufly, and, as it is faid, perfect in all their parts, as almoft all the kinds of Spiders, and many more. Others, on the contrary, undergo fome changes before their parts are finifhed, which is the property of a great number of Worms and Caterpillars; for when thefe infects affume the form of a Nymph or Chryfalis, under this fhape they fuffer another change, or rather, the fame evaporation of the fuperfluous moifture which the animalcule fuffers in the egg when it iffues from thence, or which they themfelves have alfo fuffered in their egg, before they underwent this change,

Hence it is, that as fome infects come from the egg perfect in all their parts, Tab. I. fig. 11. *a.* fo, on the contrary, others are forced from thence imperfect as it were in their feveral limbs. But as the former often change their skin, though they be not afterwards transformed into Nymphs, which are difcoverable by certain new limbs, before they grow mature, and are rendered fit for generation, fo the latter fometimes caft their skins, and when they throw off the laft, under which they acquire the form of a Nymph, and are furnifhed with new limbs, Tab. XVI. they likewife attain to maturity; after which neither the former nor the latter infects caft their skin or grow, but apply themfelves, with all their ftrength, to the bufinefs of generation; and then, pleafed as it were with their paft employment, they die in peace, unlefs it be fo ordered by nature, that they are obliged to feed their young, and for that purpofe muft neceffarily live fomewhat longer. Indeed, moft infects are found of fuch a nature, as fcarcely to live more than four hours after the time of their laft change, and the bufinefs of generation is over: fo that nature feems to exert her utmoft ftrength upon this occafion, and the beginning of life in one little animal is the end of it in another, as we fee every day in the motion of the weights affixed to clocks, one of which defcends whilft the other afcends. But we fhall treat more fully of thefe matters in their proper place.

To explain our obfervations on the egg fomewhat more amply, and as far as may be proper in this place, we muft add, that we have remarked, that the infects which proceed inftantaneoufly, or perfect, from the egg, as well as thofe which iffue from thence in the form of Worms, are difpofed and placed in the fame egg as clofe as can be, and without any food in their power, in the fame manner as the Worm and Caterpillar lie ftill and compofed, without the leaft food, when they have put on the form of a Nymph, as we have obferved. This will be clearer when we come to the fourth order of tranfmutation.

Further, as the Worms and Caterpillars beforementioned, when changed into Nymphs, are fluid like water, and fwoln on account of their limbs being extended by a fuperfluous moifture; and as they cannot move, although they live and breathe; fo we have found, that our animalcules lying in their egg, and being alfo fluid like water, are incapable of the leaft motion. Wherefore, as the infect formed from the Nymph, or rather the infects themfelves, hidden under the form of Nymphs, do not appear, till thefe redundant humours have been diffipated, and their limbs have acquired fufficient ftrength to burft the outward skin; fo likewife thefe animalcules, which are protruded from the egg, either perfect or imperfect, do not part with thefe their eggs or coverings, before the fuperfluous moifture is expelled, and their feeble limbs have acquired fufficient ftrength, fo as to be able to break through the outmoft skin, wherein they are involved as in a fhell, and to quit it, as foon as it is burft or perforated.

If we attentively confider what has been hitherto advanced, which is indeed of great moment, and productive of many ufeful conclufions, we fhall be inclined to determine, that thofe eggs, wherein the animalcules lie ftill without food, in the figure of Nymphs, and which, for that reafon, often have the form of the animalcules that are to proceed from them, ought not, properly fpeaking, to be called eggs, but Nymphs in the form of eggs, or oviform Nymphs. The former infect, for this reafon, though yet in the egg, may not be improperly called a Nymph-animal oviform, or in the appearance of an egg; as the latter may be denominated an oviform Nymph-vermicle, or Worm-Nymph. Nay, the egg, as it is called, or rather, the coat wherein they are wrapped up, ought to have the appellation of their skin, rather than that of the fhell or

egg,

egg wherein they are to be generated or formed: but we have already touched upon thefe obfervations concerning the skin in the foregoing pages, when we treated of the Nymphs and Chryfallides cafting their skin.

As our intention is to offer fome rules and orders of tranfmutation, which comprehend all the changes that happen in the infects known to us; we fhall fix our eyes firft on the changes of thofe infects, which iffue inftantaneoufly, as it is faid, out of the egg, and which have already gone through the whole procefs of their change, or accretion of their limbs in their mother's womb; that is, when by the continual increafe of their invifible yet effential parts, as they are called, they have become perfect animals in the egg, they have undergone no other change out of it, except only the evaporation before mentioned; nor are they to be afterwards fubject to any other change or accretion into a Nymph, which is alfo performed only by evaporation.

This we fhall offer as the firft, fimpleft, and plaineft method of change in infects, and from this we fhall proceed by degrees to fuch as are more obfcure, complete, and difficult of comprehenfion, mentioning fome fo intricate, that, it feems to many, they cannot be explained at all. This notion hath been fo eftablifhed by cuftom, that for want of a more proper term, the bodies have been called eggs; fince to a perfon, who views them flightly and fuperficially, not even the leaft veftige of any diftinct limb appears in them.

The firft order of change then, according to our fyftem, is, when the infect, lying in the egg or fkin without food, after fome days evaporation and diffipation of the fuperfluous moifture, creeps out of it, perfect in all its parts, fo that afterwards it is not changed into a Nymph, nor undergoes any other remarkable mutation. But fince this infect, before it hath arrived to its full bignefs and proper growth, by means of the food that is given it, is fometimes obliged to caft its skin, like the Worms or Caterpillars that are changed into Nymphs; and fince, under the laft change of the skin, its limbs alfo undergo fome tranfmutation; it is therefore the infect ought to be confidered as a real Nymph, at the time it is in its laft skin; for when this is caft, it is obferved to be fit for generation, and to have come to its maturity and full vigour, and not before.

Since therefore fome infects are changed after they have caft the laft skin, which may be exemplified in the long-legg'd Spider defcribed by Goedaert; we fhall, for this reafon, confider this infect as a kind of Nymph, and for diftinction fake call it a Nymph-animal. Not that we would have any perfon tied down to make ufe of the terms we have offered, being fatisfied, if the orders of thefe changes be as diligently, accurately and diftinctly obferved as they are in nature, for in this lies the principal and only knowledge.

If we further ferioufly attend to this change, we fhall plainly fee, that it not only agrees with the accretion of the limbs in fanguiferous animals, but alfo with that epigenefis, or fuperaddition, obfervable in plants or vegetables; this therefore we would have underftood of the orders of changes, and fhall accordingly make the like application.

To give fome inftances of what happens in fanguiferous animals, none feems more proper for that purpofe, than the accretion of the limbs in a Frog, Tab. XLVI. *a.* for as the young Frog is very vifible, by means of the black fpot which we fee in the egg, fo we find that this is nothing but the very animal, in the fame manner as we have fhewn in infects. But as the infects are not produced with their food, fo no other difference can be difcovered in this cafe, than that the young Frog iffues forth with its proper aliment; and it is alfo found to be wrapt up in a certain membrane like the infect, though it ftill feeds for five days within it.

Further, as the Frog, immediately after the burfting of this membrane, finds matter to feed upon, for it lies in the midft of it, fo likewife are the infects readily fupplied with nourifhment, when their eggs are broken; fince fome of them are placed within, and the reft without, and upon the fubftance on which they are to feed.

To purfue the analogy, as the Frog proceeds from its egg without legs; fo we fee a great many infects creep out of their skins without them. And as the legs and the reft of the Frogs limbs increafe in procefs of time, fome within, and others without the skin, fo that at length it refembles a Nymph of the fecond order, in the fame manner we fee, that all the limbs of infects, as well thofe that are in, as thofe that are out of the skin, grow by degrees, until they are changed into real Nymphs.

Laftly, as the Nymph of the Frog beforementioned cafts its skin in procefs of time, and expofes to open view its hidden limbs, which we faw through the skin before, and by degrees attains its full maturity and ability for generation: fo, after the fame mnnner, we obferve, that the Nymphs of infects after fome time caft their skins, and fhew their covered limbs, and, like the frogs, are rendered capable of propagating their fpecies.

But we fhall treat this matter more at large in the following fheets, when we lay before the reader our own moft remarkable experiments on Frogs; the principal part whereof has been performed before the grand duke of Tufcany, the fublimity of whofe noble and accomplifhed mind, is infpired with a generous and benevolent affection for the liberal arts and fciences.

Let us now confider the vegetable kinds, Tab. XLVI. *a.* for as we fee thefe grow from a feed, which infolds fome leaves, or a very tender fprout; in like manner, we find that infects ripen into a fuller and ftronger habit from their feed, which contains all their limbs, or rather the animal itfelf wrapt up in the skin.

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For the fame reafon that plants come in time to maturity, and fwell under the cover wherein the flower lies, as the infect does in the Nymph: fo likewife we obferve, that infects infenfibly approach to a more perfect maturity, and by flow degrees fpring in their covering, or the Nymph, in which are all their limbs, as the flower is placed in its proper covering: this we fhall hereafter demonftrate in the Clove Julyflower, Tab. XLVI. *b*.

Laftly, as flowers at length break out from their husks, and become capable of producing new ones by generation and running up into feed; in like manner infects proceed from their Nymph, as the flower from the husk, and are alfo rendered fit for generation and repofiting their fperm. And as propagation is performed in plants, by the union of their feed with the moifture of the earth's womb, infects perform the act of generation, by the conjunction of the fruitful, and, as it were invifible particles of the male's fperm, with the confpicuous, vivifick, and fenfitive feed in the female. This feed of the female continues and perfects the life, motion and fenfe which it enjoys, when the fpermatic virtue of the male is thrown into it; and it is in this continuance of motion that the fruitful conception of the feed is properly faid to confift: but we fhall hereafter explain this matter more at large, by particular examples.

A catalogue of the infects which are referred to in the firft order of natural changes, called the Nymph-animal.

HAVING explained our firft and moft fimple order of changes, in which we have confidered the animalcule, which comes perfect from the egg, as a real Nymph when it is about to caft its laft fkin; it now remains, that we fhould give a catalogue of infects which belong to this order: and upon this occafion we fhall briefly enumerate fuch of them as we have in our cuftody, as we fhall do alfo with regard to the Nymphs, Chryfallides, and diftinct fpecimens of the four orders, together with feveral other things not unworthy the fpeculation of the curious, which we preferve in our cabinet, and by the affiftance of which we are able to demonftrate to the eye every thing hitherto, and that fhall hereafter be, advanced.

To the firft order of tranfmutations belongs the Spider *, which proceeds immediately from its egg, and has no vermicular ftate; this has been alfo obferved by the moft accurate Martin Lifter, who in his elaborate treatife on Spiders fays, "Thefe are hatched from the eggs, "perfect and complete in all their parts." Chap. II. Of the generation of Spiders.

I keep, for this purpofe, the largeft of all Spiders, that is, the venemous, Brafilian kind, which has crooked, black, very fharp and big claws, or rather darts, and alfo has two arms, which are in all refpects like fhanks or legs.

I alfo have the great downy Phalangium, or Tarantula.

Alfo a very remarkable Spider which Dr. Padbrugge fent me from the Cape of Good Hope. It is of the colour of fcarlet velvet, and covered thick with a fine down, in which is the colour. It is as big as a grain of a fmall French bean, with an oblong body, and broad breaft; it has fhort legs, except the two foremoft pair, which are very long; the fecond pair are fomewhat fhorter; the third is very fhort; but the fourth or laft is fomewhat longer, and all of them are covered thick with red hair. The breaft is fo clofely united to the belly, that they cannot be feparated from one another; therefore this Spider is in that refpect like a Lobfter; it has two fhort arms, and two ruddy tranfparent ftings or darts, but its eyes can't be feen on account of the thicknefs of the hair.

I have alfo the American fpecies of Spiders, which has rough, thick, and very long legs in comparifon of the body; the belly is fomewhat fwelled and briftly, its darts are very much bent and crooked like claws, but the arms are fhort in comparifon of the legs, being not above a third part of the length of the fore pair. It has eight eyes, which are neatly ranged in two rows; its breaft is like an oval fhield; it turns the eyes to the extreme parts, and bends itfelf a little on the infide, behind the joint of each leg or fhank, in the fame manner as the fkin finks between the ribs in lean and thin people; but this is common to a great many Spiders big and little.

I have alfo one of the Holland fpinning Spiders, which, in colour and figure, refembles Mouffet's largeft fpinner, but it is not half fo large. I have obferved in this fpecies, that each of its eight legs confifts of feven joints; thus the firft joint at the breaft is very fhort; the fecond is much fhorter and formed like a ball; the third is the longeft of all; and it is for the fake of this only, that the other joint feems to have been made, that this third joint may be moved with the greater eafe and expedition; the fourth is fomewhat bent, and by degrees grows thicker; the fifth is the longeft except the third; the fixth and feventh decreafe in proportion, whereof the latter is provided

* The generical characters of the Spider kind, as eftablifhed by Linnæus, are, that they have eight legs, and the fame number of eyes, placed on the back part of the thorax. The common houfe Spider, the water Spider, Tarantula, and others, are of this genus; and thefe diftinctive marks exclude fome infects, called by others by the fame name, placing them under other heads. The long-legged Spider having but two eyes, is properly an Acarus.

with

with two large, crooked, black claws, accompanied by others of a fmaller fize*. The animal makes ufe of all thefe to run down the web, and to guide and govern it.

I cannot determine, whether the Englifh Spiders have the fame properties, as Lifter fays pofitively, "All Spiders have three joints "in their legs." But fince this gentleman thinks that all Spiders have two antennæ, or horns, which are inferted in the head next to, and above the darts, I fhould not agree with him in this affertion; for though I have never feen the Englifh Spider, yet I can eafily fee from other foreign kinds, and their limbs, that this is repugnant to the nature of Spiders. In order to folve this difficulty, I fhall briefly relate what I have obferved, concerning this matter, in my Spinner. By examining the Spider before defcribed, I found that thofe two joints, and all the other legs, are fixed to the breaft; but with this difference, that the place of their connection with the breaft is higher, on account of the thicknefs of the hair; and this I judged to have been done, left they fhould impede the action of the limbs, wherewith the fpicula or darts are united, and that thefe joints may move with more eafe. I have alfo obferved, that they confift of fix, or perhaps of feven joints, which I fhall not pofitively affirm; wherefore they are, for this reafon, like legs, as Dr. Lifter has alfo obferved, where he fays, "Thefe, like feet, confift of certain joints."

But what deferves the greateft attention, is, that every one of thefe has a claw fixed to the end of it, that is fomewhat crooked and blackifh: wherefore, thefe may very properly be called the fifth pair of legs; and the rather, becaufe they have their mufcles on the infide, as the other legs have, and are rough with hair and prickly briftles. However, many reafons induce me to think, that they ought not to be reckoned among the legs, fince in the whole tribe of Spiders they are not fhaped in this manner, but in a great many they refemble the claws of Lobfters and Scorpions. This is vifible in the Flea-Spider, in which thefe limbs very nearly refemble a pair of tongs or pincers, only that they want the great toe, as appears by one now in my cuftody; I am obliged to refer to this, as nothing remarkable or ufeful can be obferved at this time, for I am writing this in the month of December; but I can demonftrate this fo clearly, in another fpinning Spider I have, that there can be no room for doubting: for firft, we may fee two darts or arrows in this; then, thefe arms are formed with fuch wonderful art, as not to be inferior to the inimitable workmanfhip which we admire in our own hands.

Thefe arms are divided into different joints, at the end of which we fee a fmall concave and convex part, covered with hair: this refembles, in afpect, a piece of the white of an egg divided into four parts. At the end of this fmall part, there is in every arm a little rifing fomewhat like a finger. There are alfo on thefe fmall hairy parts, others worthy our obfervation, each of which is joined on the inward concave fide, to the bafis of thefe hairy parts, fo as that the latter may protect, and, for the greater fafety, hide the former. The firft of thefe parts is divided into two joints placed one upon the other, to the lower of which is joined a real but obtufe forceps, of a mixed light red and blackifh colour, whereby the arms are connected together. To the other joint, which is fomewhat higher, is joined an obtufe or blunt little claw, of a colour inclining to a bright red. We further find, that another fmall, and, as it were, blunted part, is articulated at the root of the firft part, whereon lies the forceps; on the end of this are three fmall toes or crooked claws, which are not placed, nor formed, in the fame manner, and whofe moving mufcles are hidden in the fmall blunted part. Thus it is plain, that thefe arms are differently framed, according to the different kind of the Spider.

From thefe inftances, therefore, it is clear as the light at noon day, that thefe limbs or members ought not to be called antennæ, feelers or horns, but real arms, and that neither Spiders nor Scorpions have any horns. But as the brachia, or arms, before defcribed, are formed with amazing art, I have therefore thought proper to preferve them dried; in order to have them ready to fhew on any occafion.

I likewife obferve, that the long-footed Spider has no feelers or horns, but its arms are provided with, at leaft, one crooked black claw, that reaches beyond the end of the arm. The legs, with refpect to the joints, are like the legs of the fpinner before defcribed; and what is properly called the foot, feems to be divided into two feveral joints, that have two claws at the end of them. But I cannot further inveftigate thefe matters at this time, being now in the midft of winter, and having no Spiders, but fuch as are dried and preferved; in which, but efpecially in the large venomous ones, that I keep, it is very evident that Spiders have no horns or feelers.

I alfo have Lifter's fmall crimfon Spider, but as this is alfo dried, we cannot difcover the proportion of the ends of the arms, but we may fee that they are fomewhat thicker than the legs.

I obferve in the green, fmall, and long-bellied Spider, of that illuftrious Englifhman, that thefe arms have likewife a plain claw at the end of them. The fame is obfervable in other Spiders which I have, nor is there any that has not the fore joint armed in the manner beforementioned.

* There is a remarkable property in the Crab, in breaking off a wounded limb at a particular joint. This has been exemplified at large in the Philofophical Tranfactions. If the laft joint of a leg be wounded, the Crab, by a peculiar motion, breaks off the limb at a peculiar place above, and a new one grows in its place. The fame happens in fome fpecies of the Spider.

I think, I obferve a very remarkable texture in the arms of the Wolf Spider, which I cannot now thoroughly inveftigate.

As to the Spider's teeth, I do not find that they have been hitherto defcribed by any author, fince the parts fuppofed to be teeth, are, in reality, the creatures weapons or darts, by which it takes and kills little animals, afterwards fucking their blood. But to fpeak firft of the darts, it is to be obferved, that they are two crooked, kind of horny, and fharp parts, like the claws of birds of prey, and are fituated in Spiders immediately under the eyes: but they are articulated with two ftrong, firm, kind of horny and mufcular fubftances, which are obferved to be fixed under the bottom of the breaft, in which the eyes are placed. I have feen clearly in my Spinning Spider, which is like that of Mouffet, as I before obferved, that thefe firm little bones grew on the infide, like certain blackifh eminences or juttings like teeth, between which the fpicula, or darts, were fecurely and fafely inclofed, as the moveable blade of a knife is in the groove of its handle.

I have not, on the narroweft infpection, been able to find the leaft opening in thefe darts, by which the infect might eject any venomous liquid; fuch an opening as we fee in the teeth or ftings of the Worm called the Sica, or Sicarius, or Affaffin, or fuch as it is faid are to be feen in the teeth of Vipers. I have not even been able to find any apertures in the ftings of the biggeft venomous Spider called Phalangium, though as long as half a joint of the firft finger.

Neither could I ever perceive that Spiders, however irritated, difcharged any virulent matter, though I have fpared no pains or attention to obferve them. Doctor Lifter alfo feems to have made the fame remark, and I fhall willingly fubfcribe to his opinion; till experience may inform me otherwife.

It is very furprifing, that fuch ftrong and folid mufcles fhould be contained in the horny fubftance of thofe parts, to which the ftings are faftened. I have a method of extracting thefe mufcles entire, in anatomizing the infect; and the fame may be obferved of the mufcles ferving to move the claws of Crabs. No doubt, thefe parts agree much with the internal claws or pinchers of Scorpions, who likewife carry them under their eyes; and was it true that Spiders, on wounding any animal with their darts, difcharged a poifonous liquor along them into the wound fo made, we might then fay, that the darts of this infect and that of the Scorpion were perfectly alike; excepting this, that the Spider's weapons are placed on the fore part of its body about the mouth and breaft, whereas that of the Scorpion is fixed to its tail; befides, the Spider has two darts, and the Scorpion only one. But it is above all things worthy obfervation, that in the Spider with two eyes, thefe darts are joined and formed into real forceps, as the indefatigable Lifter has obferved, and I have myfelf difcovered this to be the cafe in fome long footed ones which I dried: fo far therefore thefe parts agree in make with the internal forceps of Scorpions.

As to the true and proper teeth, I have found them fituated forward on the lower part of the thorax, immediately under the points of the darts, where they fhut one clofe to another; in the fame manner that I have obferved in the little crabs, and as may be feen in the Cray-Fifh. They are alfo fafhioned in the fame manner, but of a fubftance not fo horny. On pulling out thefe teeth, it appears that they are united with certain other little pieces; which may not improperly be called articulated briftles. We have here therefore a fatisfactory folution of the phenomenon, fo judicioufly obferved by doctor Lifter, viz. that there may be found in the excrements of Spiders, fome particles of the Flies they have devoured. His words are, "You would imagine they only lived by fucking the juices of the Flies they catch, if you were to view nothing but the dead carcaffes of thofe Flies; but if you attentively examine the excrements of the Spiders, you will find in them particles of their fkin or coat." Spiders, therefore, actually devour fome parts of their prey, and fuck the juices from other parts of it, which they can eafily and conveniently do, when they fqueeze it between the denticular procefs of thofe parts, where their darts are inferted, and draw in its blood and juices. They are able to do this the more eafily, as their darts terminate oppofite to their teeth; for under the teeth there may be obferved a little piece like a lip, and this procefs covers fome part of them.

As to what regards the eyes of thefe creatures, I cannot at prefent examine them to my fatisfaction, the days being fhort, and the weather very cold and cloudy; befides which, I have but one of thefe Spiders in my cabinet, placed there for the fake of obferving, whether the fevereft froft would not entirely ftiffen it, as is the cafe with Butterflies, and common Flies. But as I had doctor Lifter's work, it induced me to undertake the diffecting of this fingle Spider, though I had at firft intended to fay nothing of Spiders in particular at this time. I difcovered that its two uppermoft eyes were fomewhat bigger than the others. This difference is very ftriking in the Flea-Spider, as it was evident from a drawing I formerly took of this laft infect; in which I have reprefented its ten eyes. But neither can I now examine that kind of Spider fo accurately as I could wifh. Which way foever the fact may lie, I find the two eyes that are placed above the eight others, are reprefented very fmall in my drawing.

I have carefully examined alfo, whether in the afperæ arteriæ of the Spider, there were any openings; but I could find none in the thorax, nor any which ran into the belly: I only difcovered in this kind of web Spider an oblong member,

member, like the penis of many animals, fituated in the middle of its belly, on the outfide of its body, on a very prominent place near the thorax; and near this member there were two yellowifh fpots in the form of moons, covered with a fofter fkin than the other parts of the belly.

But not to dwell too long upon thefe parts, the following are the principal of the others, which occurred to me on examining this Spider; befides eight eyes fituated in the head and thorax, and on the fore part under the eyes, the darts with their joints; behind and under thofe darts in the thorax, appeared its mouth and teeth; then beyond thefe were two arms with their claws, and after thefe eight legs, each with feven joints and two claws at their extremities; add to thefe the belly, with its peniform member, and the down, and fharp briftly hairs, with which the fkin both of the body and legs are all over covered.

I cannot yet fay much of the internal parts, but I may affirm, that I faw very diftinctly the mufcles of the legs, claws and darts; I could likewife perceive that the thorax was quite full of mufcles, fo as hardly to contain any thing befides the mouth, heart, and fpinal marrow; but I have not obferved thefe mufcles of the thorax diftinctly enough, to be able to affirm any thing certain concerning them.

The mufcular integument of the belly was very eafily feparated from the inteftines which it contained; and under this there appeared an elegant piece of net-work, like an omentum or cawl, confifting of globules delicately fixed to one another, and of a whitifh purple colour.

On opening this omentum, I thought I could perceive the abdomen, which was fhaped like the tendril of the vine; then firft appeared pretty diftinctly the inteftines, through which there ran here and there whitifh veffels, which I took for productions of the afpera arteria. Next there came in fight a tranfparent yellowifh mafs of a globular figure, which might be taken for a ftring of eggs, if the peniform particle or member already obferved had not indicated the creature to be male; and confequently this fomething elfe.

The little bag, in which the Spider carried the ftuff for its web, like foft glue, was twifted into many coils of an agate colour; and upon breaking it, the contents were eafily drawn out into threads: but as I made all thefe obfervations in hafte, and in the firft diffection of a Spider that I ever fet myfelf about with attention, I neither can, or dare vouch, for the perfect certainty of them all. I refer to fome other opportunity a more careful furvey of this moft curious fubject.

In the mean time, we have great reafon to be concerned that doctor Lifter did not think proper to finifh his excellent work with the anatomy of all thefe parts; which would certainly have been a moft valuable addition to fcience. He has laboured ftrenuoufly in the other parts, every where giving proofs that he wrote his hiftory in an accurate and regular manner from his own obfervations. This is the reverfe of what the generality of modern writers practife, who do nothing but plunder each other, and then, like Æfop's crow, adorned with the feathers of other birds, and weakly glorying in their borrowed finery, perfuade themfelves that what they have pillaged from others, is the offspring of their own brain, though they do not fo much as underftand it. We may the more readily excufe fuch high notions in them, when we know they are no more than the monftrous productions of a heated imagination.

Of the Flea Spider I preferve two kinds. Thefe feize their prey by a fudden leap, and therefore nature has provided them, as well as other Spiders, with eight eyes, and a moft acute fight: it is more difficult to judge of this fight in the Spiders that make webs; for fo far from taking notice of a finger put clofe to their eyes, they neither exprefs any concern at it, nor attempt to run away; whereas, let the moft minute animal fall into their nets, they immediately perceive, and lay hold of it. This apparent infenfibility on the one hand, and readinefs of perception on the other, has made fome philofophers think the web Spiders had no eyes, but received information only concerning their prey, by the tremulous motion of their web. When thefe gentlemen further confider, that what look like eyes in Spiders, never appear when viewed with the microfcope of a reticular form, as is the cafe in the Scorpion: they more roundly deny that they have any eyes. But it by no means follows from the web Spider's never leaping upon its prey, or from its never running to it, unlefs when taken in its net, that it has no eyes; and this conclufion muft appear yet weaker, on confidering that eyes are as diftinctly perceivable in this kind, as in the Flea Spider, and withal are difpofed in the fame manner. As to the argument drawn from the parts which look like eyes in web Spiders, not being formed in the reticular manner, as in other infects, it is equally unfatisfactory: for what difference is there between its eyes being placed fingly in different parts on the furface of the body, as in the Flea Spider, and their being gathered into one net as in other infects? befides, the eyes of Spiders thus fcattered, are much larger than thofe which form the netted eyes in other infects; fo that, every thing duly confidered, there is reafon to affirm, that Spiders have a more perfect fight than the generality of other infects, except the Libella or Dragon Fly, which appears to have very large, or very numerous complex eyes, fo as to afford an opportunity of trying upon it many curious experiments. Thus, has nature difplayed her wonders, even in thofe little animals, which, at firft fight, appear to many beneath their notice; at the fame time that fhe ordains the largeft animals to proceed originally from principles

principles, or eggs, as little confpicuous as thofe from which thefe minute infects derive their beings: this we have already obferved.

But let us return to the Flea Spider, in which the providence of nature is very confpicuous, having fupplied it with a thread by which it may fwing, and be fecured from any fudden fall; if at any time it fhould fail in the fprings it makes: however, this thread becomes an obftacle to its catching any, except very little, animals, when it has remained any time in the fame place. Though this infect makes ufe of no net to catch its prey, it fpins itfelf, like many other Spiders, a web to fly to, and to hide in, on being purfued. Another thing worthy our notice in the Flea Spider, is, that on pointing your finger to it at a diftance, it wheels and turns itfelf about every way you move and turn about the finger; and runs off, on your putting the finger nearer. Laftly, as I have already obferved, there are amongft the Flea Spiders which I keep in my cabinet, fome, the extremities of whofe claws are found like the forceps of Scorpions, except that they are not jointed, but fhut in a manner like the forceps of the Cray-Fifh.

I have befides thefe a Hedge Spider, which, to hatch its eggs the better, carries them about, as it were, in a cafe, with wonderful folicitude and affection; infomuch, that when the fkin forming this cafe, which hangs to the hinder part of its body, is by any accident broke off, the little infect feeks after it with as much earneftnefs and induftry, as a Hen for her loft Chickens; and when found, faftens it again to its place with the greateft marks of joy. A defcription of this Spider may be feen in Harvey's Treatife on the Generation of animals, and more perfectly in doctor Lifter, who with great propriety calls it the Wolf Spider *.

I preferve alfo in my collection, fome bags in the fhape of eggs or pearls, in which Spiders put up their eggs, and hang them, as in a bafket, to the beams and floors of houfes. I have fometimes obferved fmall Flies to come from thefe nets, and have by me fome of the Flies thus produced. It would demand too much compafs, for this place, to enlarge at prefent on this fubject as much as it deferves.

To conclude, I preferve likewife that fpecies of long-legged Spiders, which Goedaert, to whom the learned world are obliged for the drawing of about four hundred infects, has exactly defcribed, in the forty-ninth experiment of his fecond volume. He there, in the drawing of this infect, moft evidently demonftrates, that it is a true Nymph at the time when it is about to throw off its fkin for the laft time; for its legs at this period are lengthened in a very remarkable and furprifing manner. The accurate Lifter has alfo remarked, that Spiders fometimes are not fit to enter upon the bufinefs of generation, till they are almoft two years old; which, no doubt, proceeds from this, that nature intends they fhould fo long continue growing, before they part with their laft fkin, and with it, the form of a Nymph. Before this time they are not fit for generation, and after they are, they never change their fkin.

We are likewife greatly obliged to the late accurate James Hoefnagel, painter to the emperor Rudolphus, who has left us the drawings of thirty-five Spiders, and of about three hundred other infects of different kinds; which drawings, taken after the life, have been fince publifhed from copper-plates, with the privilege of his imperial majefty, and are in no refpect inferior to thofe of Goedaert.

Wenceflaus Hollaar has alfo applied himfelf to this ftudy, and deferved well of the publick, by his moft exact drawings of the infects preferved in the Arundel Mufæum. It were greatly to be wifhed, that all thofe who would be thought to have any extraordinary knowledge of infects, did the fame, that by their joint labours this branch of natural philofophy, which is by no means of the leaft account, may be brought to perfection. A thorough acquaintance with the difpofitions and actions of thefe little animals, would enable us to form the better judgment of the difpofitions and manners of innumerable others.

Before I quit the confideration of Spiders, I think it will be agreeable to fhew in what manner thofe kinds which fpin webs, or live upon Flies, get from one tree to another, which they will do; even when feparated by a running water. It will be firft proper to mention, that the Spider's thread is by no means fingle, but almoft always double, and fometimes even ten or twelve fold. This may be eafily feen by throwing down a Spider, and immediately examining the thread to which it hangs. Or it may be obferved, with ftill greater eafe and certainty, by feparating the hinder part of a Spider from its fore part, and then drawing out the thread, and afterwards examining it. As therefore the Spider's thread is generally made up of two or more parts, after defcending by fuch thread, it afcends by one only, and is thus enabled to waft itfelf from one height or tree to another, even acrofs running waters; the thread it leaves loofe behind it, being driven about by the wind, and fo fixed to fome other body. This opinion of Spiders making ufe of a double thread, has already been advanced by Henricus Regius, profeffor of medicine at Utrecht, and that eminent naturalift Francifcus Redus.

But the accurate doctor Lifter produces fome diffierent obfervations on this fubject; he fays, that Spiders, in this cafe, fhoot out their threads. His words are as follow: "Some "Spiders fhoot out their threads in the fame "manner that Porcupines do their quills, with "this difference only, that whereas the quills

* The Wolf Spider makes no web, but lives at large upon dry banks and heaths, perfuing his prey or feizing them by furprife; and is very nimble and very bold.

" of the latter are entirely feparated from their " bodies when thus fhot out, the threads of the " former remain fixed to their anus; as the fun's " rays to its body." And in another place, " Spiders that are middle-aged, or of a mode- " rate bignefs, truft themfelves to gentle winds " by means of a thread, and thus endeavour, " as it were, to afcend into the clouds, and " the upper regions of the atmofphere." As to the firft of doctor Lifter's affertions, I cannot at prefent take upon me either to countenance or contradict it; I only wifh he had explained himfelf more clearly; for how is it poffible that the thread of a Spider, which is fo fine and flender, fhould be fhot out with force enough to divide and pafs through the air? Is it not rather probable that the air would ftop its progrefs, and fo entangle it, and fit it rather to perplex and obftruct the Spider's operations? I know very well, that a man may drive out his urine to a confiderable diftance, in the form of a flender thread; but this urine is a liquid, which is not the cafe with the Spider's thread; befides, it does not appear that the Spider carries all the matter of which it compofes its threads, in a fingle cavity, fo as to be able to throw it fo far, if it could do it, even in a folid form. Moreover, there feems requifite for this purpofe a great ftrength of mufcles, and a confiderable exertion of fuch ftrength; whereas that part of the Spider from which its thread iffues, does not appear to have any mufcles: thefe are conjectures only, which time will overthrow or confirm.

As to doctor Lifter's laft affertion, there is no great difficulty in comprehending it. I have myfelf often obferved fmall Spiders fupported and driven about in the air, by means of a thread, in the fame manner with that little paper machine called a kite, with which children divert themfelves. If therefore doctor Lifter, in faying that Spiders when come to their full growth fhoot their thread, means only, that they let it fall loofe from their bodies, to be taken hold of by the wind, and lengthen it by a continual fending out of the matter that compofes it, there can be no objection to his doctrine. For my part, nothing more as yet appears to me on this occafion, than that all Spider's threads are drawn from the infect's body, by its own weight or effort, without any compreffion while it defcends or moves forward, as the threads of the Silk-Worm are drawn, and by no means ejected, from the bags in which the matter forming them is lodged. I can yet more eafily comprehend how, Spiders without giving themfelves any motion, may, by only compreffing their anus, fpin out a thread, which being driven by the wind, may ferve to waft them from one place to another.

The dart of the Tarantula is faid to occafion a peculiar frenzy *, which the fame authors fay is cured by mufick, but this feems an impofition. A very curious gentleman lately arrived here from Italy, has affured me, that it is looked upon as a mere fable, even in the country where the creature is moft common; and that none but the lower fort of people, beggars and vagabonds, pretend, on being hurt by thofe venomous creatures, to find any relief from mufick. They pretend this, that by impofing on the credulous, they may live without betaking themfelves to honeft labour. And thus we fee amongft ourfelves, the people called Gypfies, by fetting up for prophets, prey upon the ignorant and illiterate.

To finifh what I have to fay in this place concerning Spiders: I am to obferve, that doctor Lifter very accurately divides them into what he calls fowlers, viz. fuch as take their game in nets, or by ftinging it, and into hunters with eight eyes, which he diftinguifhes from thofe with two eyes and long legs. Doctor Hooke has favoured us with very curious drawings of the beft kind, and I intend to publifh diffections of them on fome fucceeding occafion; that fo the hiftory of thefe infects may, by our joint labour, be brought to the perfection it deferves, and fupply us with new motives to love and reverence God, the author of all the miracles we obferve in them: this fhould be the fole end of all our endeavours and ftudies.

I fhall next refer the Acarus † to the firft order of mutations, as it iffues from its egg, perfect in every thing but fize, which it afterwards acquires by degrees.

In the fame order too I fhall place the common Loufe ‡, which has a Nit for its egg; but as this iffues very fuddenly from its egg, or rather, as what we call the egg is in reality the Loufe itfelf, which only waits to be freed from the fuperfluous moifture that furrounds it, to efcape from its cover; it is an eafy matter to conceive, how this little infect can multiply fo faft, that people fay in fport, but it is no more than a jeft, that a Loufe may fee its fourth generation in the fpace of twenty-four hours §. Thefe Nits muft be laid in a place that is warm, and moderately moift, to produce any thing. This is the reafon that many Nits laid on the hairs in the night-time, are deftroyed by the cold of the fucceeding day, and fo ftick for feveral months,

* Bonone mentions a large Spider in Sardinia, whofe bite proves mortal in a few hours.

† The generical characters of the Acarus, are, that it has eight legs, and in each leg eight joints, and has only two eyes. According to this diftinction, eftablifhed by Linnæus, and now adopted by all naturalifts, the long-legged Spider, and many of the creatures infefting birds and beafts, and commonly called Lice and Fleas, are truly Acari.

‡ The generical characters of the Loufe, according to the Linnæan fyftem are thefe: it has fix legs, contrived for walking, not for leaping as in the Flea; the eyes are two, and they are of a fimple ftructure; and the body is divided by indentings into feveral lobes.

§ Lewenhoeck, who put a male and female Loufe under a ftocking which he wore night and day to favour their breeding, found that the female lays from fifty to a hundred eggs; and computing the natural increafe from what he had feen, fays, that in eight weeks, one Loufe may fee five thoufand of its defcendants.

till they at laſt come to loſe even their external form.

In examining a Louſe by the microſcope, its white veins and other internal parts appear, as likewiſe a moſt wonderful motion in its inteſtines, on account of the tranſparency of the internal parts of this inſect. When the Louſe feeds, the blood is ſeen to ruſh like a torrent into the ſtomach, and its greedineſs is ſo great, that the excrements contained in the inteſtines, are ejected at the ſame time, to make room for this new ſupply. But I ſhall treat of theſe inſects in particular, as ſoon as I ſhall have finiſhed what I propoſe ſaying in general of theſe that belong to the firſt order.

What I have already mentioned is but by way of parentheſis, that my countrymen might know ſomething of the ſtupendous actions and conſtructions of ſo ſmall an animal, and be thereby incited to praiſe the author of nature, who has here placed in one point of view ſo many and ſo great wonders. The great uſefulneſs of the microſcope will alſo appear from the preceding obſervations, ſince, by diſcovering to us the muſcles, veſſels, and internal parts of ſo ſmall an inſect, it acquaints us with the incomprehenſible perfections of that great being, who could not only create, but impart life and motion to ſo minute organs. There is another advantage alſo in microſcopes, viz. that in tranſparent animals, they give us a much more perfect knowledge of the motion of their inteſtines, than any we can obtain in other creatures by diſſecting them. This benefit of the microſcope has been already taken notice of by the illuſtrious Hooke, in his Micrographia, or collection of obſervations made with microſcopes, a work lately publiſhed in Engliſh, and dedicated to his Britannick majeſty.

I have reaſon to believe, but for want of ſufficient experiments I dare not as yet affirm, that the Lice of other ſanguiferous animals, and the Lice of inſects, with thoſe that live upon plants, or ramble about the fields, belong to the laſt mentioned order or claſs *. Mean time it will appear evident, in treating of the fourth claſs, that there are ſome tree Lice, deſcribed by me under the title of animalcules, found in the excreſcences of the black poplar, which belong to the ſecond order.

Neither can I affirm, that the Tick, or Ricinus of Aldrovandus, though placed by me in this claſs, does really belong to it; though I have in my collection a good ſpecimen of this inſect.

I likewiſe refer the Bug which lies in bedſteads and furniture to this firſt claſs; as alſo the Crab-Louſe, though I have not as yet made experiments ſufficient to determine perfectly the nature of this laſt inſect.

I have alſo in my collection the Louſe of the Whale, which is almoſt an inch long, and half an inch broad, of a very ſingular form, and all over covered with a ſhell †.

After theſe, I rank the Flea ‡ in the firſt claſs. This inſect alſo ſprings from a Nit, in the which it elegantly changes to a red colour, like other inſects in the Nymph ſtate; the changes it undergoes, while as yet in the ſtate of the Nit, and the manner in which it from white becomes black, are eaſily diſcernable by the help of the microſcope : nor are theſe obſervations of little uſe or importance, as I ſhall hereafter prove at a proper ſeaſon. I have been told that Doctor Lewenhoeck obſerved a Flea at Delft, which, about the end of ſummer, iſſued from an egg in form of a Worm, and then ſhut itſelf up in a caſe till the enſuing month of March; but I ſhall not as yet affirm the certainty of this obſervation; neither ſhall I determine whether the Flea wore in its caſe the figure of a Chryſalis, or a Nymph; if it did, the inſect muſt belong to the third, and by no means to the firſt order. I ſhall uſe the firſt opportunity of exactly obſerving this inſect, ſo as to know the certainty of what has been advanced concerning it, as ſuch enquiry cannot be attended with any great trouble §.

I likewiſe place in this firſt claſs an inſect which is generally found in ciſterns where rain water is kept, and which Goedaert has deſcribed by the name of the Water-Louſe, as may be ſeen in the third volume, letter X. But as the ſtructure and diſpoſitions of this little animal differ greatly from thoſe of the com-

* Redi, who very accurately examined this ſubject, found Lice upon the Lion and the Tiger. He calls all thoſe on quadrupedes by this name; and thoſe on birds, Fleas; but he is in this miſtaken, the diſtinctive characters are to be found in the ſtructure of the parts, not on the creatures whereon they feed. The ſame author obſerves, that the Lice bear no proportion to the bigneſs of the creature on which they live, the Starling having a Louſe as large as that of the Swan.

† The common Fly is ſubject to a particular inſect which lives upon his head; this is ſo minute that few have obſerved it; its ſize is calculated by La Hire of the French academy, to be not more than a four thouſandth part of that of the head of the Fly. This is of the Acarus kind, having eight legs.

The Crab-Louſe upon the human body is of the ſame genus with the common one of the head, but a different ſpecies. It is deſtroyed by mixtures with water, in which crude mercury is boiled.

Even the Snail is ſubject to be infeſted with a kind of Louſe, but in a very ſingular manner; for this creature, which has eight legs, and is of the Acarus kind, lives equally on the ſurface of the body, and within the inteſtines, running in and out at its pleaſure. It is uſually ſeen alive in the inteſtines, when they are examined by the microſcope.

‡ The common Flea is an extremely ſingular inſect, there being no other ſpecies properly of its kind: the generical characters are theſe; it has ſix legs formed for leaping, the eyes are only two, the organ which ſerves for a mouth is bent downwards, and the belly is roundiſh and compreſſed. Only the Flea of the human body has theſe characters; what is called the Pulex Sturni is an Acarus, and the reſt of the inſects which have received this name from inaccurate obſervations, belong to other genera.

§ Though the Flea is peculiar in the human kind, it is not ſo with the Louſe. Multitudes of animals, birds and beaſts, are infeſted with Lice, and though of different ſpecies upon moſt kinds, they all have the characters here deſcribed, and are properly of the Pediculus or Louſe kind. Inſects have alſo leſſer inſects living upon them, particularly the Beetle; but though theſe are called Lice, from their living on other animals, they are not of that kind. The Louſe of the Beetle, as it is commonly called, has eight legs, whereas the proper Louſe has but ſix: this creature is properly an Acarus, and ſo of the other.

mon Loufe, though it be at the fame time equally fingular and remarkable, I have given drawings of it, both of its natural fize, and as the microfcope reprefents it, in the fpecial treatifes on infects of this firft clafs, under the name of the water arborefcent Flea *. Thefe drawings are exhibited in Tab. XXXI, and a complete defcription of the infect immediately follows that of the Loufe.

I now pafs to the Afellus, or wood Loufe, which is found of all fizes †, and may, partly for that reafon, and partly for others, be ranked in this firft clafs. I have in my collection three kinds of this infect; the firft is the common ground Afellus; the fecond has great, black, prominent eyes, a diftinct head, and a thorax like a hood; the third kind is very remarkable for folding itfelf into a ball when handled, and remaining for fome time in that pofture.

I likewife preferve feveral skins thrown off by Afelli, floughs or dead skins, which ftill exhibit the exact figure of the infect. Thefe floughs produce a great fermentation, when mixed with acids; whence we may juftly infer, that they contain a great deal of alcaline falt, and therefore may be of great fervice in curing the dropfy, ftone, and gravel in the kidneys.

I likewife have in my collection fome fea Afelli. I give them this name, becaufe they are found in falt-waters. The largeft of thefe is one that meafures two inches and a quarter in length, and one inch and a quarter in breadth; it confifts of eight rings, of a firm and bony fubftance. I have likewife a very fmall Afellus of the fame kind, which I caught in the North fea near Petten. Doctor Padbrugge fent me from the ifland of Ternate, another fpecies of Afellus, under the name of the fea Loufe. It is almoft half an inch long, confifts likewife of eight rings fomewhat coloured, and, like the Sea Hedge-hog, or Echinus, has a border of fmall prickles; but thefe infects have no legs.

I preferve alfo fome other kinds of fea Afelli, more curious than thefe already mentioned, amongft which there are four, whofe fhape is like that of the Shrimp. The firft of thefe, which is the biggeft, is an inch long, has a flender body, feven legs on each fide, like the ground Affellus, and large horns which meet in a fharp point; the laft ring of the body in this fpecies is much longer than the reft, and running out into a three-pointed extremity. The fecond and third kinds are much fmaller, but almoft of the fame ftructure. The fourth differs from the three kinds already mentioned in this, that its fore legs are much longer than its whole body, and thefe are divided into four very diftinct joints. It is likewife the fmalleft of the four kinds, not exceeding half an inch in length, even when its claws are ftretched out to their greateft extent.

I preferve alfo a broad fea Afeilus, fent to me from Iceland; it is an inch long, half an inch broad, and compofed of feven rings, including the head and tail. Its antennæ or horns are fharp and fhort, its eyes are brown, its fix foremoft legs are armed with fharp and crooked claws, and near its tail, on both fides, are two flat fins. Olaus Borrichius obferves, that the whole body of this infect appears to be fupported by a fimple bone, not unlike in fhape to a fmall date, but of a horny or cartilaginous fubftance. I have fome of the fame, kind but very fmall, which I took in the falt-water river that runs by Amfterdam. I can alfo fhew a very uncommon kind of fea Afellus, which I caught near Petten; it is fcarce an half inch long, of a globular but fomewhat oblong form, refembling a pear, with a pretty long tail, and fome fins. I preferve with thefe fome Scrophulæ, which belong to the genus of Afelli. The firft of thefe I caught on the coaft of the North fea; it is very fmall, always runs, and fometimes fwims flantingly, and when afhore leaps as the Flea does.

Amongft the Scrophulæ which I have taken in the frefh waters and rivers of Holland, is to be mentioned, that kind which is called Snel. This has a pretty way of running flantingly, and if we may believe the tales of fifhermen, it readily kills the Perch, by running itfelf fuddenly into the gills of that fifh. We have no experience to confirm this tradition. I know, indeed, that this little animal is furnifhed with arms fufficient for the purpofe: being held in the hand, it excites a kind of tingling: now the gills of Perches, and indeed of all fifh, are fo tender and delicate, that it is almoft impoffible they fhould not die on receiving wounds in that part, through which all the blood of fifh is circulated, in the fame manner that the blood of other animals is all circulated through their lungs. This kind of Scrophula is found equally in frefh and falt waters.

After thefe follows properly the Worms, which fome have called the inteftines of the earth. Thefe proceed immediately from the egg, and do not afterwards undergo any change, coming forth at their full perfection. The females, from their firft hatching, have their little eggs, which are very diftinct and perceptible. I obferve, that this genus may be divided into many fpecies.

Though it is no hard tafk to diftinguifh in feveral kinds of Worms and Caterpillars the males from the females, by carefully examining them, but chiefly by diffection, to fee if they have any eggs within them, yet they fel-

* Latter diftinctions do not permit us to give this fingular creature the name Pudex or Flea. It is of the monoculous kind, the charactersof which, according to Linnæus, are, that the fore feet are branched, and are found equal for fwimming or for leaping; that the eye is fingle, but compofed of three, and that the head has a cruftaceous covering.

† The characters of the Afellus are, that the body approaches to an oval form, and the tail is fimple, and not foliated. The number of legs is uncertain, ten, fourteen or fixteen. The genus is now called Onifcus. The plain tail diftinguifhes it from the Shrimp kind; and fome others which approach to it in many refpects, but by their leafy or foliated tails are referred, though fmall, to the Crab kind.

dom copulate while in the Worm ſtate; ſo that Goedaert ſeems to advance a paradox, when, in the ſeventy-fourth experiment of his firſt part, he repreſents as a male Worm, an inſect which he afterwards, on its having undergone the uſual change, calls a female, in the ſeventy-fifth experiment. This is the ſame as if an infant, who we called a boy, we ſhould afterwards, on his arriving at the ſtate of maturity, denominate a woman. But I ſhall ſpeak more of this hereafter. In the mean time I muſt remark, that my reaſon for animadverting thus freely on the miſtakes of others, is, that ſucceeding writers may take the ſame liberty with me, by which means truth will at length univerſally triumph; for I am well aware how much we are apt to be pleaſed with our own conceits, and how often deceived by that fondneſs, ſo as to take them for the true repreſentations of nature. However, I have no great reaſon, I think, to dread the ſevereſt inquiry into my obſervations, ſo that I with pleaſure give them up to the examination of thoſe who ſhall think it worth their while to compare them with the things themſelves, which is the only method of coming to a certainty, in inveſtigating what belongs to the animals of which I have been treating. Nevertheleſs I muſt candidly own, that many of the particulars I have mentioned as yet, appear ſo obſcure to me, that I can at moſt but conſider myſelf as a novice in this buſineſs; beſides, that words are wanting often to expreſs the wonders which occur in the ſtudy of inſects.

Scorpions * belong to this claſs of the inſect kind; they are produced from an egg like the Louſe, as will appear in the account I ſhall give of them in particular, after the hiſtory of the water arboreſcent Flea.

I am of opinion alſo, that the Leech † is to be arranged in this claſs, though I have no particular experiments to confirm that opinion, except its being found of almoſt all ſizes. It is very remarkable how firmly this inſect will faſten itſelf to the ſides of the glaſs veſſels in which it is kept, ſo as not to be ſeparated from them without the greateſt difficulty. This, I apprehend, it effects by preſſing its body cloſe to the glaſs, and then ſwelling it in the middle, ſo as to repel the water in which it ſwims. Thus, if we apply to a ſtone a round piece of leather, with a ſtring fixed to the center of it, and then pull this ſtring, the ſtone and leather unite very firmly together ‡.

I refer alſo the Scolopendra, or Centipes, to this claſs, as I have met with this inſect of all ſizes, and could never yet diſcover that it changed its form. I have got one of the largeſt kind, which is even a ſpan long, and was ſent me from the Eaſt Indies. I preſerve alſo other kinds of this inſect, as the Lybian Scolopendra of Mouffet, and the water Scolopendra, and in fine, ſome Juli, or Gally Worms, which we ought to rank with this kind.

After theſe inſects follows the Snail, as proceeding directly from an egg, and not being liable afterwards to any change. I preſerve a ſort of Snail, in which, on cutting off the head, is found a ſtone, called the ſnail ſtone, ſaid to be ſerviceable in the gravel and ſtrangury. Under this ſtone we always find the heart, which retains a pulſation, and is, with the veſſels that ſpring from it, of a very white colour. As on cutting off the Snail's head, this ſtone is always to be met with, it ſeems probable, that it ſerves for the ſame uſe as the Os Sterni does in other animals: it is further obſervable, that nature has formed Snails in ſuch a manner, that they void their excrements at their neck, breathe at their neck, and have there alſo all the parts ſubſervient to generation. I have obſerved alſo, that every Snail is both male and female; in a word, a perfect hermaphrodite: the penis is formed like that of the Whale, and is of a ſurpriſing length. But I ſhall hereafter treat of all theſe particulars more at large. The Engliſh authors, who publiſhed a catalogue of the plants that grow in the neighbourhood of Cambridge, have already obſerved, that Snails are hermaphrodites.

To come to a concluſion, I preſerve alſo in my cabinet the teeth of Snails, which are flexible, and of a horny ſubſtance; as likewiſe the heart of a Snail with its auricles, preſerved in a balſam, and properly inſected.

All the inſects hitherto mentioned iſſue directly perfect into light, and are never changed into motionleſs Nymphs; for their eggs, without any intermediate ſtate, afford young inſects exactly like the old ones, which grow to their due bigneſs in time, whilſt their limbs acquire firmneſs and ſtrength. Nor do they in this reſpect differ from thoſe other animals, which Harvey tells us proceed from a perfect egg, though before they attain their full growth, they may be obliged to change their ſkins, and ſome of them in their laſt change of their ſkin undergo ſome further changes: for this reaſon I have conſidered them as Nymph animals. Beſides, ſome of them, like mankind and quadrupedes, hatch their eggs within their bodies, and are therefore viviparous. This is the caſe with Scorpions, and ſome ſpecies of Snails.

* The generical characters of the Scorpion, as now eſtabliſhed by Linnæus, are, that it has eight legs, with claws on the forehead; eight eyes, two on the upper part of the thorax, and ſix at the ſides, with a tail armed with its ſting.

† The Leech, like the Earth Worm, conſtitutes a particular genus of inſects; the characters are few and plain; the body is ſimple, and is expanded into breadth at each end: we have two kinds common in ſhallow waters, the Leech uſed for bleeding, and the cylindrick kind.

‡ Morand, in the memoirs of the academy of ſciences at Paris, has accurately deſcribed the mouth of the Leech; it conſiſts of five parts, two lips, a hollow for receiving the blood, an inſtrument to pierce the ſkin, which is compoſed of three ſharp points, and an Œſophagus for ſwallowing the blood. The Leech will live in oil, which is deſtructive of moſt other inſects, if only rubbed upon their ſkins. The Leech, when taken out of oil and put again into water, caſts a thin and very delicate ſkin.

The natural changes of the first class or order of insects, exemplified in the Louse; with an explanation of what relates in general to the other three classes.

THAT I may give a singular and satisfactory specimen of the first class of insects, I shall here insert a letter, formerly wrote with great care to Mr. Thevenot, as it contains a complete and exact account of the limbs and parts of a Louse, both internal and external. This example, by which I propose to illustrate the first class of insects, and the examples I shall give, in their due places, for the other three classes, will enable the reader to form a competent judgment of the changes, which all other insects undergo, according to the different classes to which they belong. It must be allowed, however, that whatsoever pains we may take to arrange them, there will still remain, even amongst those of the same class, very remarkable differences; and some of those differences will be in the mutations they undergo. This will most clearly appear from our experiments relating to the fourth class, in the case of the worm-like Nymph of of the Asilus Fly, and in the egg-like Nymph of the common Fly; between which there is no small difference, though they belong to the same class, and are liable afterwards to the same changes. This accidental difference may also be seen on looking over the figures of animalcules, which I have given under each kind in the special histories of the three other classes. It appears very strikingly in the Crysallides of Caterpillars, as they are exhibited in the designs of the indefatigable Goedaert; for though they all belong to the second mode of our third class, yet one Chrysalis differs in many particulars from another: this difference is, however, far from being what is called essential, it only consists in some part of the external forms.

From the first class of our changes, we shall now select the Louse as an example, and represent by figures, the changes which happen in its parts, till it comes to its full growth. The Libella, or Dragon Fly, will serve us for the second class; and the Ant for the first mode of the third; the nocturnal Butterfly for the second. Lastly, we shall give the common Fly as a specimen of the fourth class; and I shall afterwards illustrate these several changes by the accretion of the limbs in a Frog, and the budding out, or shooting, of the parts of a flower.

Though the foregoing natural changes, and the comparisons of others which will be made in treating of them, may be thought sufficient for giving a clear idea of the practices of the insects contained under the four classes, into which I have arranged them, and of the differences between each class; nevertheless, I shall add to the first class, a separate and satisfactory account of the manner wherein the parts of Snails grow and are changed. I shall do the same by the Ephemeron, or Fly of one day, in the second class. In the third class I shall exhibit, according to the first mode, all the changes of the Bee, with a complete dissection of that insect and the horned Beetle; and the same both in descriptions and by figures of the common day Butterfly, according to the second mode of the third class. Lastly, I shall give in the fourth class an account of all the changes which the Asilus, or Gad Fly is subject to, and illustrate them with plates. I shall, besides these, insert various other histories, all which will not only throw a light upon each other, and represent clearly and distinctly the changes of the four classes in the exact manner wherein they happen, but, what is much more advantageous in this kind of study, they will display such miracles of wisdom, power, and goodness in the great Creator, as cannot fail powerfully to incite us to love and adore him. This, indeed, is the great purpose I propose to myself in my inquiries concerning these natural mutations.

To set forth clearly and distinctly the orders of the transmutations in the Louse and Dragon Fly, the nocturnal Butterfly, and common Fly, and to exhibit more plainly the changes of each of them; as also that I may be able to demonstrate those, wherein the orders of the changes agree or disagree among themselves: I shall use the same number, and observe the same rule in explaining the five respective figures. For though there be not the same necessity to proceed in the same manner in setting forth all the figures of the changes and accretions observeable in those insects; as for example in the change of the Louse, which is only a simple augmentation; yet, since we see five distinct changes in the Libella, or Dragon Fly, and other insects, whose figures we exhibit before they attain their full age, and are rendered fit for generation, we have been, as it were, obliged to treat the Louse in the same regular manner, in order to render the whole more exact and uniform, as we have before done in comparing the Frog with the flower or vegetable increase.

We have not observed that method also in the particular histories of Bees and the rest, as well because their anatomy are subjoined to those accounts, as that the classes we have advanced, seemed calculated to exhibit a certain general rule, whereby all the changes of insects produced by nature may be tried and examined.

Finally, every thing marked in numbers in the explanations of the figures, is delineated in its natural bigness; but the Animalcules, to whose figures the numbers 1, 2, 3, &c. are affixed, are represented as they are magnified by the microscope; while some others that are characterized by 1, 2, 3, are reprefented to the life. This has appeared to me the proper method of proceeding in this affair, for two reafons; firft, left the order of the number fhould be broke by increafing or diminifhing the figure; fecondly, becaufe fome of thefe infects are fo large of themfelves, that there is no need of a microfcope to delineate them.

To follow nature as near as we could, we have put the white animalcules, or little animals of our four claffes on a black ground, which we have not done with refpect to the other coloured ones. This appeared the more neceffary, as Goedaert reprefented a briftly Caterpillar, the figure whereof we have in one of our tables, without any hair at all, which error was probably owing to his not laying it on a black ground, whence its white hairs were not difcernible.

To make the rule of our four claffes the ftronger, we have alfo been careful to felect animalcules that are fo well known, that there is no neceffity to illuminate them with colours. And we are confident, that our figures are fo accurately executed, that it would be unpardonable to daub them with paint. We come now to treat of the Loufe, which I now intend to do, comprehending the whole doctrine concerning it in the form of a letter.

TO THE MOST ILLUSTRIOUS

Mr. THEVENOT,

Formerly embaffador from the king of FRANCE to the republick of GENOA.

Most illustrious Sir,

THE omnipotent finger of God is prefented to you in the following fheets, in the anatomy of a vulgar and loathed infect, the Loufe; wherein you will indeed find miracles heaped on miracles, and will be amazed at the wifdom of God, moft clearly manifefted in a minute point. Let the world admire the mafterly ftrokes of Apelles: here you will find the complete fabrick of the vifcera of all the animals in the world, formed with the moft exquifite workmanfhip, and abridged, as it were, in a particle of a line in meafure. What mortal, illuftrious fir, can attain to this by reafon? what other hand, but that of God, can inveftigate and frame fuch things? The fpirit and grace of God, which he beftowed on mankind, has rendered fome capable of fearching into fuch fublime miracles and fecrets, and to lay them open to the view of others. Though the Ægyptian Magi could imitate the other miracles which God performed by Mofes, they were not able to produce thefe animalcules by their magick art, as the facred writings teftify. * "Aaron "ftretched out his hand with his rod, and "fmote the duft of the earth, and it became "lice in man and in beaft; the magicians did "fo with their inchantments to bring forth "lice, but they could not; then the magicians "faid to Pharoah, this is the finger of God." I cannot fo properly, illuftrious fir, offer thefe obfervations to any other as to you, fince I know no other that fets a due value on fuch things, according to their dignity.

The EXTERNAL PARTS.

BEFORE I exhibit the internal parts vifible in this fmall and defpifed animal, I fhall defcribe its external parts, and fhall fhew every thing remarkable in the head, thorax and abdomen.

The fhape of the fore part of the head is fomewhat oblong, that of the hind part fomewhat round; the fkin is hard, and being ftretched, is tranfparent like parchment, and has here and there briftly hairs. At the extremity of the fore part is the probofcis, or fucker, Tab. I. fig. IV. *a*. feldom vifible, fince it is always drawn to the infide; I fhall therefore defcribe it when I come to the throat and ftomach. On each fide of the head are the antennæ or horns *bb*, which are alfo covered with a fkin like parchment. Each of thefe is divided into five joints, elegantly covered with briftly hair, and feveral white veffels are feen through thefe horns. Behind thefe are the eyes *cc*, which feem to want thofe hexagonal divifions obfervable in other infects, and they appear to be incompaffed with fome few hairs.

The neck is very fhort, the breaft is divided, as it were, into three parts; in the middle of which, on the back fide, appears, as it were, a fmall fhield. On each fide are placed fix legs *dd*, each of which confifts of fix joints, fome larger than others: they are very delicately adorned with briftly hairs, and many whitifh veffels are feen through them. The ends of their legs are armed with a fmaller and larger ruddy and

* Exod. viii. 17, 18.

pellucid

pellucid claws *ce*, ferving thefe infects in place of a finger and thumb; for by the former they take hold of a perfon's hair, and by the latter, they are able to afcend and run nimbly. Under, at, and upon the breaft, where it is joined to the legs, and, as it were in the very center of it, there appears a fhort whitifh groove or channel, which is confpicuous through the middle of the abdomen, appears of a brownifh colour, fig. v. vi. and has very ftrong motions. On either fide of this groove or channel are two bright little parts, like the larger before defcribed, whofe appendages they are, and which rife confiderably on the infide of the breaft, and are there alfo tranfparent.

The abdomen is divided into fix parts, and at the end of it, on the under part, the body terminates as it were in a cloven tail. Befides thefe in the middle of the lower part of the belly, there is to be obferved a whitifh fpot like a point, which is alfo tranfparent, and moves diftinctly up and down. On the fides and extremities of the belly, which is all over hairy, are obferved fome pellucid, ruddy, little bodies; and over the whole belly, a great number of white veffels are vifible, fig. iv. *gg*. The like are difcernable in the back and breaft. The skin of the abdomen is made like the ends of our fingers, confifting of fmall grooves, but this ftructure does not hold through the whole, and not at all at the extremities of the abdomen; for there, as well as in the whole body, it is fomewhat firm, like clear parchment, and when roughly preffed, it makes a noife and breaks.

The anatomy of the INTERNAL PARTS.

TO obtain a perfect knowledge of all thofe parts, which I have hitherto mentioned in general, there is no other way but to diffect the creature. I fhall therefore now give an exact defcription of all the minutiæ relating to the internal parts; for by this means we fhall have a complete idea of the external alfo.

If we begin the diffection in the upper part of the abdomen, and cautioufly open the skin there, blood immediately iffues from the wound, and this being received into a fmall glafs tube, Tab. II. fig. i. *aa*, and viewed with a powerful microfcope, is feen to confift of tranfparent globules, as cows milk: the fame has been likewife difcovered in the human blood for feveral years; it is found to confift of ruddy globules fwimming in a clear liquor.

It is, however, a matter of doubt, whether the blood in its veffels has any globules, for when drawn from them it may eafily acquire that figure; this may at leaft be afferted of the ruddy part of the blood. I have therefore often refolved to put a fmall glafs tube into the artery of a dog, and with a microfcope to view the flowing blood. For thus, by analogy, it may be poffible to determine with fome certainty, whether the human blood, before it is taken out of its veffels, contain any globules. I am the more in doubt concerning this matter, becaufe there are veffels difcovered in the body, which appear much finer than the globules themfelves vifible in the blood. By this means alfo may be known the true difference between the arterial and venal blood; for in the latter only, I have hitherto obferved thefe globules, having never examined the former: Nor fhall I pofitively affert, that there are originally globules in the Loufe's blood, for they may be eafily formed by the intermixture of the blood with the fat, and fome wounded particles of the vifcera or bowels, which confift of a congeries or heap as it were, of globular parts; as I fhall fhew in its proper place. Wherefore, more time ought to be fpent in this anatomy, than I can devote to it at prefent, being engaged in many other ftudies.

Tab. II. fig. ii. Immediately under the skin are certain mufcular fibres, which move the annular divifions of the abdomen. I have obferved three diftinct kinds of thefe mufcles, fome a little broader *a*, others narrower *b*, and a third fort with two bodies *c*. One may fee that thefe mufcles extend themfelves from one annular divifion to another, and that fome are much fhorter than others. This little animal is very full of mufcles, particularly at the extremities of the abdomen; fince the motion is ftrongeft in that place, and the refpiratory points or orifices for refpiration are placed there, by the affiftance of which the Loufe takes in the air, and by a manifeft act of infpiration and expiration, draws it into the body, and again difcharges it. When thefe mufcles are drawn from the body, they feem as if they confifted of but one fibre, but if they are dried upon a thin and clear glafs, and wafhed with fpirit of wine, which takes off the impure fat that adheres to them, their fibres and joints appear diftinctly to be made up of globules.

Under thefe mufcles the fat and the tracheæ, or air veffels, come in view; nor could I ever hitherto difcover any veftige of a heart in this upper part of the abdomen, as is ufual in other infects, wherein the heart is always placed in the upper part of the abdomen and back; but I found clearly by this diffection, that the Loufe otherwife agrees in all its parts with other infects, as will hereafter plainly appear; therefore I have more diligently fought for the heart, but in vain: this may probably be owing to its extreme fmallnefs, fince it is very difficult to find it in the larger infects, as in the Horfe-Fly. There is alfo another impediment, which is, the ftrong and continual agitation of the ftomach in this infect, being hardly a moment at reft, from which there arifes an unavoidable inconvenience in inveftigating the heart.

The particles which I take to be the fat of the Loufe, are for the moft part very fmall, but extremely numerous, though we may difcover it in a larger fpecies or kind of fat particles; the figure of the fmalleft kind of particles is ufually globular, but that of the greater is more irregular. They are of a clear tranfparent colour, like gelly, but all the other parts of this animal are not of that colour.

The ramifications of the trachea, afpera arteria, or windpipe, conftitute the principal part of this infect; a very confiderable number of them are found in the head, breaft, belly, legs; nay, and in the antennæ or horns. We may likewife obferve, that they are connected and fupported by the fat, as I have found in other infects: and thefe are the white veffels which are feen through the tranfparent body, as I have obferved in the hiftory of the external parts. The reafon that thefe pulmonary pipes are feen through the skin, is, that they are of a filver colour, or light bright mother of pearl, and therefore afford a very agreeable fight, whilft the animal lives. They conftantly keep this colour, nor will they ever fade, for their ftructure is fuch, that they remain always open.

As to their compofition, it confifts of a double matter; a part is compofed of rings, which refemble the cartilages of the trachea, or windpipe, in man. It appears very diftinctly by the microfcope, that thefe rings often bend themfelves round, in order to form a cavity and open pipe, Tab. I. fig. VII. *a*; but this does not happen fo often as in other infects, becaufe the rings of the Loufe are fhorter: they are alfo more curled and twined *b*, in likenefs of a Serpent, and feem every where interrupted *c*. It may alfo be obferved, that where the afpera arteria, or wind-pipe, is divided into branches, there thefe rings are largeft *d*, but they are afterwards infenfibly divided into fmaller *e*. The other part of thefe veffels is membranaceous, and is fituated in the interftices of thofe rings; and by its affiftance the rings may conveniently bend and turn themfelves, as is known to happen, particularly in thofe wonderful motions of the ftomach, which is furrounded by a great number of air-pipes.

I have hitherto omitted examining whether thefe pulmonary, pipes within the body, likewife fhed a little fkin at the time the Loufe cafts its coat, as I have obferved to have happened in the Bombyx, or Silkworm, and in almoft all other infects. However, the fmaller thefe pulmonary pipes are, the fewer rings they have, until at length they appear like more membranaceous threads.

I may venture to affirm, that the pulmonary pipes cannot be more conveniently viewed in any fpecies of animals that I have hitherto known, without diffection; fo that we cannot contemplate their fituation and courfe, with greater admiration, in any animal than in the Loufe. But I have by me a very curious and familiar apparatus, by the affiftance of which, I can at any time demonftrate it with the greateft certainty.

Tab. I. fig. IV. The orifices of the XIV pulmonary pipes are feen in the outward fkin of the Loufe; one (1) of which is on either fide of the breaft; and on each fide, on the extremities of the abdomen are placed fix, 2, 4, 3, 5, 6, 7, which I exhibit in the figure in one fide only. I have alfo thought I fometimes faw one pair of air orifices between the fecond and third pair of legs; however, I will not be pofitive in this matter.

Tab. I. fig. VIII. Thefe orifices are the refpiratory points, one of which is fituated on one fide, between the firft and fecond pair of legs, and fix on the extremity of the belly, 1, 2, 3, &c. thefe points fwell a little there, like a fmall nipple *aa*, and in their circumference, feem to have a flight rim or border, which appears fomewhat ruddy and tranfparent as the place itfelf wherein they are fixed is alfo of a light red and bright colour; they are a little bent towards the infide, and immediately after the tegument of the extremity of the abdomen fwells out. All the points are like that which I have obferved to be placed in the breaft. *b*.

Tab. I. fig. IV. From every refpiratory point there iffues a branch of the trachea *bbb*, which foon after forms a vifible anaftomafis or inofculation with fome branch of the trachea, that proceeds from another point, and both clofe into one canal: the fame holds alfo in all the XIV apertures of the lungs; fo that the air, which is drawn into the body by one refpiratory point, may be fpread through the whole. Nor is it there only that the pulmonary pipes unite, but this holds equally in thofe which are in the back, belly, and breaft; which laft is diftinguifhed by three manifeft ramifications that are joined together underneath. This matter hath been already elegantly delineated by doctor Hooke, in his incomparable Micrography; however, he could have no knowledge of thefe ramifications by any other means, but that they appear vifible through the body.

I am further inftructed by the diffection, that the pulmonary pipes may be difcovered not only in the head, breaft and abdomen, but they reach alfo to the inteftines, the ovary, fpinal marrow, brain, and, in fine, to all the internal parts of the body of this animal; all which, as I have diftinctly feen, fo I can demonftrate them to others, with the affiftance of certain experiments which God enabled me to invent in the ftudy of anatomy, that the miracles of his works might be known: for we have not even the leaft thing from ourfelves, for it is God that giveth us ingenuity.

Thefe things being well underftood, I might proceed to defcribe the other parts; as firft, the ovary, which appears next after the former, being a part placed upon the ftomach itfelf: but fince method requires us to treat, before thefe, of thofe parts which affift digeftion, and tend to the nourifhment and prefervation of the body, and afterwards of thofe which ferve for generation.

generation. I ſhall now deſcribe the proboſcis, or ſucker, the throat, ſtomach, inteſtines, and other adjacent parts. I ſhall after theſe treat of the ovary, brain and nerves, and then add ſomething concerning the outward ſkin, with which I ſhall conclude this anatomical deſcription.

The Louſe has neither beak, teeth, nor any kind of mouth, as doctor Hooke deſcribed it, for the entrance into the gullet is abſolutely cloſed: in the place of all theſe, it has a proboſcis or trunk, or, as it may be otherwiſe called, a pointed and hollow aculeus or ſucker, with which it pierces the ſkin, and ſucks the human blood, taking it for its food into the body. But this proboſcis cannot be ſhewn, on account of its extreme ſmallneſs; nor can it be diſtinguiſhed, unleſs a perſon happens to ſee it by chance.

At the extreme point of the head, when preſſed out artificially, and with a particular attention, there appears an obtuſe prominence, Tab. II. fig. III. *a.* which being hollow in the middle of the inſide, bends back into itſelf, and goes into the body, but has no aperture or opening. From this the proboſcis *b*, or ſucker, is obſerved ſometimes to proceed, and wherefore this part is, as it were, the ſheath or caſe of it, wherein it is laid up.

I cannot illuſtrate this ſtructure or machinery by a more proper example, than by that of the horn of a ſnail, which is likewiſe turned into itſelf on the inſide, and is again ſtretched out, but there is no perforation: wherefore, if the proboſcis or ſucker was placed at the end of it in this inſect, inſtead of the real eye which we ſee in the ſnail; one might in ſome meaſure form an idea how the proboſcis, or ſucker, is wrought in this inſect, and worked up with admirable art by the ſupreme architect of the univerſe.

If the whole little ſheath or caſe be afterwards examined, Tab. II. fig. IV. *c.* it is obſervable, that the upper end of it is thicker than the lower, and is ſwollen like a muſhroom; ſo that it appears from hence, that the little foot on which it ſtands is ſmaller than its top. When one preſſes the proboſcis, or ſucker, and its ſheath on the outſide, we ſhall find that the end of the latter is abſolutely blunt and reſembles the head of a pollard willow tree, haing all its branches cut off; we ſee alſo that there are here and there certain pointed parts or claws *d* in it, which, as well as the ſheath, and the proboſcis or ſucker, are of a light brown colour, and are tranſparent. I ſhall preſently ſhew the uſe of theſe claws; there is alſo a crooked proboſcis or ſucker *e* in the middle of them. The outward ſkin of the ſheath which is annexed to the proboſcis, and from which its head is prominent, is of the ſame texture with the reſt of the ſkin that covers the Louſe; for it conſiſts of grooves and pellucid globules, as I ſhall explain hereafter, when I treat of the ſkin.

If we examine that part of a Louſe's head at the time when it is ſeeking out ſome pore of ſweat in the hand, wherein to fix its proboſcis or ſucker, a ſmall line of a pale brown colour is then preſented to us, which appears viſible through the head, and has its fore part more deeply coloured. This little line is nothing elſe but the ſheath itſelf, with the proboſcis hidden in the inſide.

But before I explain the uſe of this proboſcis or ſucker, and its manner of riſing, it ſeems neceſſary to deſcribe the figure, ſituation, colour, texture and motion of the gullet, ſtomach, and inteſtines: for thus the method whereby the proboſcis performs its ſuction, will be more eaſily underſtood. The œſophagus or throat is a very ſmall canal, fig. III. *f*, which one cannot ſee at any other time, but when the blood aſcends through the proboſcis or ſucker into the mouth, and paſſes through this into the ſtomach. It is ſituated a little behind the eyes, and ſeems to be carried up above the brain: the reaſon that I think ſo is, becauſe it appears there very clearly at the time of ſuction; ſo that probably it runs immediately under the ſkin of the head. In the neck it is ſomewhat enlarged *g*, and afterwards it grows ſmall again in the back *h*, untill it terminates in the ſtomach, near which I have obſerved it, like a very ſmall, clear, and tranſparent thread, wherein a perſon that diſſects it ſometimes obſerves blood, and ſome other ſubſtance, which appears like the contents of the ſtomach. I diſcovered the whole gullet, in the action of ſucking, as before deſcribed; for it is a very difficult matter to diſcover it in any other manner, becauſe in the upper part of the back, and alſo in the head and neck, it is very ſtrongly connected with the adjacent parts.

The ſtomach, fig. III. *ii*, is lodged partly in the breaſt and back, but the greateſt portion of it is in the abdomen. When ſwollen with blood it appears of a dark brown colour, which is viſible through the ſkin, and is either a faint red, or a full or bright brown, as the contents of the ſtomach are more or leſs changed. Where the ſtomach joins the breaſt above, its figure reſembles a fork with two teeth; theſe are two hidden appendages of *kk* the ſtomach, which go deep into the breaſt, and on either ſide near the gullet and ſpinal marrow, and reach to the firſt pair of legs. Theſe are thoſe two blackiſh, tranſparent and coloured parts, which I have mentioned in general in the hiſtory of the external parts.

The part of the ſtomach connected with the abdomen deſerves particular conſideration; it is formed like an oblong bag, which is here and there continually contracted and again extended. When it is empty, it is colourleſs, and the ſtomach and its appendages are tranſparent. But as the ſtomach fills, the colour is ſeen plainly through the outward ſkin. It manifeſtly conſiſts of two coats, the outward is thicker, the inner very thin, as it is in all infects. Nay, it is probable that it has three coats, and that the third is mufcular.

The outward coat of the ftomach is furnifhed with fo great a number of pulmonary *llll* pipes as can hardly be expreffed in words. The larger branches are very confpicuous in it, but the fmalleft cannot be difcovered, except by the affiftance of the beft microfcopes. On the contrary, the inward coat is very thin; the third, which, I fuppofe to be fituated between the two former, comprehends without doubt, the mufcular fibres of the ftomach, by the help of which it performs its wonderful motions. The coats of the ftomach, efpecially the outmoft, appear to confift of very many globular little grains, which are very irregular in form; but whether thefe little grains properly belong to the texture of the ftomach, or whether they are rather particles of fat, which cover the ftomach, whereby the pulmonary pipes are gently moved, I could not well difcern; only this I know, that the greateft part of them, when often touched, retire from the ftomach.

Underneath, in the abdomen, on a little rifing or prominence, nearly in the middle of the ftomach, there is feen a certain little part *m*, which doctor Hooke apprehends may be the liver; but I fhould rather take it to be the pancreas, or fweet-bread, though there want fufficient arguments to prove it. Its colour is not properly whitifh, but fomewhat inclining to yellow; and it is fo ftrongly connected with the ftomach, that it cannot be eafily feparated from it. If this be laid before the microfcope, it may eafily be divided into many little grains like glands, but thefe are not very tranfparent. When it is accurately viewed by the microfcope, the pulmonary pipes alfo appear in it. The fubftance of this little part is more firm than that of the reft, for when it is extracted from the body and dried, it is but little diminifhed. It is of a very irregular figure, and is formed divers ways in almoft every Loufe, being fometimes greater and fometimes lefs; but it is always finifhed in the fame general manner, by reafon of its bendings and fituation over the ftomach, as is evident from the five different figures of thefe little parts, which I have delineated to the life from the microfcope, in fig. v. 1, 2, 3, 4, 5, of Tab. II.

At the lower region of the ftomach is feen the pylorus, fig. III. *n*. and immediately from this, the inteftinum tenue or fmall gut *oo*, which is extended on each fide, and formed like the ftomach: this is alfo provided with a great many pulmonary pipes. At the end of this fmall gut, which is for the greateft part bent in a ferpentine manner, or like the letter S, are difcovered four fmall veffels *pppp*, which the fagacious and excellent anatomift Marcellus Malpighius, has called the fwollen veffels in Silk-Worms; but thefe are ftraighter and lefs inflected in the Loufe; they are confiderably long, and of the fame texture with the inteftines. Thefe four little veffels are properly four inteftina cæca, or blind guts, which I have found in all infects; wherefore, by inference, I call them here by this name, though I never have had the fortune to fee their extremities. They open into the inteftine, from whence they arife at the place juft mentioned. After thefe appears the little inteftine colon *q*, and at the end of that, there is a manifeft dilatation or extenfion *rr*, which is the cloaca, or place where the excrements acquire their figure; for they are very irregular, and not like thofe of other infects, which are ufually formed in a fingular and regular manner. Within this dilatation appears the inteftinum rectum *s*, which fhews its aperture, as the anus fituated upon the belly between the divifion of the tail *t*; and juft under this the fkin is very briftly.

As to the motion of the ftomach, it is truly admirable; infomuch that one might fuppofe it an animal within an animal, by reafon of the ftrong agitations, contractions, dilatations, corrugations and expanfions, all which belong to it, and ftrike one with amazement, the whole being plainly feen through the body. Thefe appear plainly at the time when the ftomach is full of food, but they are beft of all feen, when the blood paffes into it at the time of fucking; for then it is fometimes obferved, that the remainder of the old aliment is mixed with the new, and is fhaken and agitated up and down, and on every fide, in the ftomach. This may be feen the more diftinctly, as the colour of the contents is more dark.

Hence one may eafily conceive what ftrange changes and emotions the pulmonary pipes on the ftomach undergo at that time, and after what various ways the air contained in them is preffed, moved, propelled, and fo purified; changed from its firft nature, and rarified within the creature. But who can difcover, by the moft diligent refearches, the ufe of the air in that place? furely no one. Yet very wonderful motions are obferved on this occafion, particularly in that little part which I called the pancreas or fweet-bread; for this being connected with the ftomach, muft obey all its motions. That any perfon may form to himfelf an idea of the motion of the ftomach, I have drawn three figures of it. When contracted, it is feen as at number 3, fig. VI. Number 2 fhews how its contractions are changed, and after what manner it dilates, is apparent from number 1. Thefe motions are continually repeated by turns, and undergo an infinite number of variations.

As to the method whereby the Loufe fucks the blood, and conveys that nourifhment into the ftomach, it is performed thus, by the affiftance of the probofcis, and its aculeus or point. Firft, if the Loufe has abftained from food two or three days, it becomes very hungry, which is difcoverable from the empty ftomach, and becaufe the creature is then wholly tranfparent; in this cafe, immediately as foon as he is placed on the hand, he feeks for food, which he will the fooner and more readily find, if the hand be firft rubbed until it grows red.

Then

Then the Loufe turns his head; which lies between the two fore legs, to the fkin, and diligently fearches for fome pore of fweat: when he finds it, he fixes his aculeus, or fucker, therein; a little after this, the blood is obferved, through the microfcope, to afcend to the head, in a very rapid, and, as it were, frightful ftream.

The Loufe has at that time matter enough to feed on in any pofture, for if it finds any hairs on the hand, by which it does not defire to defcend, it ftays in that pofture, and fucks with its head down, and its tail elevated. I have likewife obferved that it fometimes fucked with its belly upward, that is, when the hair it took hold of was bent down; and then the motion of the ftomach, and pancreas, or fweet bread, might be feen moft beautifully by the help of a microfcope.

But I fhould think the principal ufe of the claws, which I have defcribed to be fituated at the end of the fheath or cafe of the aculeus or fucker, is to affift the creature in fucking, and that the aculeus ferves for this purpofe; for whilft thefe are ftrongly fixed in the fuperficies of the inner fkin, and in the extremities of the pores, they enable the Loufe to ufe its aculeus the more freely, and to move it at difcretion, when the end of its fheath is placed firm and immovable.

Sometimes, whilft the Loufe was fucking, I have ftrongly pulled the skin of my hand afide, that by this means the fheath, or rather its claws, together with the aculeus or fucker, might be bound faft in the skin, and the Loufe could not difengage itfelf. This affords indeed a very agreeable fight. This I did with a defign, that if I could thruft the Loufe out of its place, I might the more plainly fee the aculeus: but I could never accomplifh my defire in this particular, though I had then almoft wifhed to have three hands, that I might the better find what I wanted. There are fome fpeculations and refearches in anatomy that will not bear writing, fince they almoft diftract the mind.

When the Loufe is employed in fucking, a very fmall rivulet, Fig. III. *u* of blood immediately appears behind the aculeus or fucker, which is feen through the tranfparent head. Between and before its eyes, on the middle of the head, there is obferved alfo a confiderable dilatation *x*, for the jaws are there remarkably expanded, by the blood continually afcending. Thefe parts are fo fwiftly contracted again, that there fcarce remains the leaft fign of blood after a moment, and both are performed with fuch velocity, that the dilatation can hardly be diftinguifhed from the contraction; wherefore I do not know how to explain this matter more properly, than by the fudden ofcillation of the pendulum of a clock. Behind the eyes, a fmall rivulet of blood is likewife obferved to run down within the head: this paffage may be properly called the œfophagus or gullet, fig. III. *f*, which lies behind the jaws, and grows wide again in the Loufe's neck as has been fhewn before *g*. I have chofen to exhibit all thefe as one continued canal, that my defcription may be the more clear.

After the blood has afcended to the jaws, and comes to the gullet, we obferve that it is immediately conveyed to the ftomach, and that the bifurcated appendages, as well as the ftomach itfelf, are at once filled with it. The motions of the ftomach are then remarkably increafed, its mufcular parts being diftended; for as thefe mufcular parts are then ftretched, they have an opportunity of contracting themfelves again. Wherefore it is immediately obferved, that the excrements in the large guts begin likewife to move; nay, it ufually happens that the Loufe difcharges them during the fucking.

The food being thus received into the ftomach, is agitated about in a wonderful manner; it is moved up and down, and by contractions and dilatations, which are not to be defcribed, then performed by the ftomach, is, as it were fifted. After this, it is feen, that the contents firft begin to divide into parts in the back or hinder portion of the ftomach, and they then appear like raifins preferved in jars, and are thus diftributed through the body. However, this is a falfe appearance; it arifes from hence, that the skin being divided into many grooves, is not equally tranfparent every where, and that fome difference is in this refpect feen through it, becaufe the grooves are not equally tranfparent with the intermediate parts. Nay, the particles of the internal fat not being uniformly vifible through the skin, and obfcuring the brightnefs of the skin, conduce likewife to deceive the fight, as if the retreating blood entered into many peculiar veffels. To this may be added, that the blood has not at that time a homogeneous or equal colour, for its parts feparate from each other. From thefe appearances, before I had accurately examined things, I thought that the blood was diftributed out of the ftomach, through various veffels, into the other parts of the body; but I afterwards obferved that this phenomenon arofe, as well from the blood itfelf, as from the different colours of the parts through which it was feen, and which I then took to be veffels. Perhaps others, efpecially doctor Hooke, who firft prejudiced me in favour of this opinion, have fplit on the fame rock. I have not as yet made this experiment in the fmalleft Lice, in which more peculiarities may probably be feen, than in the larger kind.

I have likewife refolved to receive the blood, when changed in the ftomach, into a glafs tube, and then to view it in the open air, or in fome dark place by candle light; but this I have not hitherto done, being hindered from making this, as well as many other experiments which I had a mind to try. In fome hours after feeding, the contents of the ftomach are obferved to become infenfibly more brown or blackifh, and

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to diminiſh ſlowly: wherefore the inteſtines are afterwards ſeen to be more and more diſtended with excrements, which ſometimes lie in them regularly divided, as it were, into globules. The reaſon of this is; that the inteſtines do not, at one and the ſame time, contract themſelves about the fæces, and therefore they caſt or extrude them out of the body at different times. I have already treated of the muſcles of the abdomen in this inſect, I ſhall now proceed to the parts of the breaſt.

In this part, and in the back, are ſeen ſeveral muſcles, which move the legs and head; and herein are alſo viſible the appendages of the ſtomach, and a great number of pulmonary pipes and particles of fat. In the ſame view is alſo ſeen the gullet and ſpinal marrow, together with the nerves ariſing from thence, of which I ſhall now ſpeak diſtinctly.

In the middle of the back is ſeen a certain tendenous point, under the ſmall ſhield there ſituated, where the ſkin does not appear to be ſo tranſparent as in the reſt of the body. This ſhield ſeems there to be hollow, being thruſt down into a little pit. At this point almoſt all the muſcular fibres are ſeen to concur, and their motion and contraction are here very viſible. As to the appendages of the ſtomach, and other parts of the breaſt and back, we have before treated of them at large.

The ſpinal marrow is properly ſituated in the breaſt, and therein reaches to the inſertion of the laſt pair of legs. When this is diſcovered, it is eaſy to judge what that ſhort whitiſh groove is, which appears through the breaſt, between the appendages of the ſtomach; for theſe appendages are placed on both ſides of the ſpinal marrow.

The ſtructure of the ſpinal marrow itſelf, does not differ much from that found in the Worm, from which the Scarabæus Naſicornis, or Horned Beetle, by the ancients conſecrated to Mercury, is produced, as is manifeſt from the hiſtory and figures of the latter. It conſiſts of three remarkable ſwellings, expanſions or dilatations, fig. VII. *aaa*, from which, on either ſide, we obſerve three nerves *bbb* to ariſe, which reach to the muſcles of the ſix legs; but underneath, or in the hinder part of it, I diſtinguiſhed ſix nerves *cc* iſſuing, which doubtleſs are diſtributed through the reſt of the viſcera, to give them life, ſenſe and motion. The loweſt of thoſe little knots, whereof the ſpinal marrow is compoſed, is formed in a different manner from the upper ones, which are alike.

The membrane which covers the marrow is interwoven with a great many pulmonary pipes, and ſeems to be compoſed of irregular and globular little parts *dd*, in the ſame manner as we have ſhewn in reſpect of the coat of the ſtomach: and this texture, together with the great number of pulmonary pipes belonging to the part, afford a very agreeable ſight in the living inſect.

I could diſcover no fibres in the nerves, which ariſe from the poſterior part of the marrow, though I viewed them freſh with the microſcope; they ſeemed indeed to be made up of a homogeneous, bright and tranſparent matter, and at their ſides were hung a great many pulmonary pipes; with particles of fat.

The origin of the marrow, where it is connected with the brain, is ſeen like a fine thread *e*. But in all other inſects this beginning of the marrow is perforated, and through its aperture or cavity the gullet paſſes.

The brain of the Louſe is ſhaped like a pear *ff*, and is divided into a right and left part. The dura mater, ſurrounding it, is formed like the membrane that covers the marrow, and is provided with pulmonary pipes and particles of fat *gg*. I can very eaſily at any time ſhew the marrow, but the demonſtration of the brain muſt be obtained rather by chance, than with any premeditated deſign or art; it is clearly ſeen when by any accident it happens to be ſtript of the parts wherewith it is covered.

The optic nerves *hh* are ſhort, and the eyes *ii*, which are connected to them, are ſo ſmall, that I could not diſſect them to my ſatisfaction; as well becauſe this operation is but aukwardly performed under miſcroſcopes, which magnify objects ſo much, that all inſtruments are too coarſe for this purpoſe. Thus much, however, I diſtinctly ſaw, that this black part in the eyes might be ſeparated or lifted up from them; which part in other inſects I call the tunica uvea, not being ſituated on the bottom, but on the ſuperficies of the eye; after this appears the tunica cornea; this ſeemed divided as it were into hexagons, as it is in other inſects, though the other was not: but that I would not affirm for certain, for we are not to ſuppoſe or imagine, but to purſue by our ſenſes, and diſcover the actions and productions of nature. This opinion, however, does not pleaſe ſome anatomiſts, who therefore eſteem all comments on the brain merely as ingenious fancies. The younger Bartholinus, who, ſpeaking of the fiction that ſilkworms had no brain, expreſſes himſelf thus: "Behold, how many are pleaſed "with their own blindneſs! who, although "they are blind, and ſhall for ever remain ſo, "yet cry aloud they can ſee, ſince theſe their "contemptible works, which ought to be re-"moved from their eyes, and buried in obli-"vion, are laſting monuments of their cloudy "arrogance; for by this means they might "afterwards ſeek for the light of truth."

Whether Lice are diſtinguiſhed by the parts of generation, into males and females, as other inſects are, I could not diſcover. Heretofore, indeed, I had ſometime remarked that Lice get upon each other; but this I could not obſerve while employed in this diſſection. I found an ovary in every one of forty, which I diſſected; this almoſt inclined me to think that theſe little animals are Hermaphrodites; and perhaps they really have in each animal a penis and an ovary together, in the ſame body, as I have found in ſnails. Whether indeed it be ſo, is ſtill a ſecret to me, for though I ſaw the ovary very diſtinctly, I could diſcover no penis, notwith-

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ftanding the great hopes I had of finding it, from having obferved that all kinds of infects have very large organs of generation.

The ovary is extended through the whole cavity of the abdomen, fo that with its appendages it reaches even to the breaft. It has an opening diftinct from the end of the inteftines, for as the upper part of the fundament is placed in the divifion of the tail, in which the abdomen ends; fo on the contrary the vagina or mouth of the ovary opens into the lower part of the abdomen, where the body is divided as it were into two parts, Tab. II. fig. VIII. as may be feen in doctor Hooke's figure. The ends or extreme appendages of the oviduct or egg-paffage are like two tubes *bbbb*, naturally joined in one point; this I have fhewn in the figure by one fide. In the oviduct *c* are feen at once perfect eggs *d*, and their rudiments *e* or principles; fo that in one ovary I have counted ten larger and forty four fmaller eggs, together making fifty-four. In the uterus I faw one perfect egg, which was fallen down ready for birth; at that time thefe little eggs are called Nits. In my figure of the ovary there are fifty-one eggs.

The ovary is double *ff* in all Lice, and every part of it is fubdivided into five oviducts *gg*, which on each fide end in one common canal; next comes in fight the uterus *h*, in which the egg *i* acquires its full perfection. Where the uterus ends, is feen a facculus or bag full of a glutinous matter *kk*, opening in that part into the uterus; this is defigned for faftening the eggs, whilft they are laying; the fame may be likewife obferved in many other infects, and particularly in Bees. I muft acknowledge that I have not feen the glutinous matter contained in this bag; but I infer, from the fituation and ftructure of the part, that the bag was defigned for keeping fuch a fubftance. After this appears the neck of the uterus *l*, and therein is a fmall dilatation or expanfion; by means of which, the ovary immediately opens itfelf into the outward womb, as may be feen at the letters *aa*.

The oviducts embrace the eggs fo clofely, that fcarce any difference is obferved between them *m*, nor can we feparate the oviducts from the eggs, without great labour; when we do this, a great many bags of fat iffue from thence, which obftruct the fight. It therefore has appeared to me, that the ftructure of the oviduct is the fame with that of the ftomach and inteftines; though the texture of this part is neverthelefs more delicate, and that the globular particles proceed from thence with greater eafe, than in the other vifcera. The oviducts are provided with many pulmonary pipes *n*, of which, as we have already obferved, this little animal has a very large number, though no bigger than a point; its ftructure and vifcera, which excel all human art, the greateft geniufes ought to be amazed at, as I have here, though briefly, yet clearly, explained and demonftrated. I am perfuaded that I might make many more difcoveries in it, if I had more time for that purpofe, fince I have completed this diffection, and difcovered thefe remarkable miracles in this microcofm or little world, in the fpace of fix days. If the learned Daniel Heinfius had fearched for thefe things in nature herfelf, and not in his own fancy, and in books, he would not have written fo poor an encomium on this infect.

As to the ftructure of the external skin of the Loufe, it affords many particulars worthy of obfervation, nor is there any thing that bears a greater likenefs to it, than ftiff and tranfparent parchment: it is in feveral places marked with fmall grooves or channels, in the fame manner as the ends of our fingers; which, when viewed with the beft microfcopes, really feem to be fo many divifions of pulmonary pipes. But the lens of the microfcope muft, for this purpofe, be carefully managed, for as it is turned one way or another, different things are feen: one cannot bring the lens nearer, or remove it further, by the leaft diftance, but fomething is immediately perceived by the fight, which was not obferved before. Globular particles, fig. IX. *a*, fometimes appear in the place of channels, or oblong pipes *bb*, though the eye is always fixed on the fame part; then between the grooves themfelves, where the skin is fimply membranaceous, globular particles *c* are likewife obferved. In other places, as in the extremities of the abdomen, the ftructure of the skin is different, for there it feems to be compofed as it were of irregular fquares; Tab. II. fig. x. *d*, wherein circular grooves *e* may be feen in one part; in another globules *f*; in a third, both globules and grooves *g*, nay fometimes the plain tranfparent skin only is feen full of points *hh*; all which, as we have before obferved of the oblong grooves, are reprefented according to the tranfparency of the parts, which have not been yet totally feparated from the inner furface of the skin; or juft as the microfcope is moved, fomewhat nearer to, or further from the skin.

Conclufion to Mr. THEVENOT.

All thefe things, moft illuftrious fir, while I viewed them. I have carefully delineated with my own hand, as you may fee by the figures annexed. I fhall now leave you to judge, whether chance, by any right, can claim even the leaft part in the moft artful ftructure of the fmall point of the univerfe, which is here exhibited; fince fo many and fuch different miracles jointly proclaim in it the divine omnipotence. Wherefore though this animal is of no advantage to the body, yet it is able to raiſe our thoughts to God; ſo that by ſeriouſly contemplating the divine Majeſty, and the glittering rays of his miracles, in this little animal, we may, with the moſt ſubmiſſive humility, change and contract our vain pride into as ſmall a point.

Then we ſhall obſerve the finger of God in theſe things, and ſhall obtain an effect, which none of the ſorcerers can imitate, or reduce into act: for the moſt ſmall and humble may drive away the devil, and rob him of his ſtrength.

The miracles of God are magnificent in every thing he has created; and even the ſmalleſt of them are the hoſt of the Lord of Iſrael; wherewith he does ſervice to his people by chaſtiſing them, when their ſins are grown to an height; that they may repent and acknowledge the ſupreme hand, which puniſhes our offences, as we are taught at large in the ſacred writings. I ſhall conclude this diſcourſe with obſerving, and ſhall always firmly maintain, that the miracles of nature are open books, whereby we are all reduced to our eternal origin, nor are we ever elevated above nature and created beings, until we conſtantly love God, and renounce all that is not God.

The end of the wonderful anatomy of the Louſe.

T A B. I.

Explains the changes of the firſt order or claſs, which are laid before the eye, by the aſſiſtance of figures; for which purpoſe the Louſe is produced for an example.

N. B. The numeral letters diſtinctly ſhew, after what manner the tranſmutations ſucceed each other: ſome of the figures are exhibited as they are magnified with the microſcope; and let the reader obſerve in general, that we have likewiſe followed the ſame rule in the examples of the ſecond, third, and fourth orders or claſſes of our changes of inſects.

No. I. Is the Nit or little egg of the Louſe delineated in its natural ſize, wherein the Louſe is contained, being yet cloathed in its firſt coat or skin. The ſame may be ſeen in fig. I. as magnified with the microſcope.

II. The empty ſhell of the egg, or the Nit's coat, caſt off by the Louſe, after it has crept out of it. It is repreſented magnified in fig. II.

III. The Louſe itſelf juſt excluded from its egg, or coat, where it is evident, how this animal has crept out of the membrane wherewith it was covered, in a ſtate of perfection; ſo that it is not obliged to undergo any other change, but afterwards grows to a larger ſize, and muſt often change its skin. Wherefore we have called the Louſe in this form, an oviform Nymph animal; becauſe it comes from its coat perfect in all its members.

IV. We repreſent the ſame Louſe ſomewhat larger, and cloathed as it were in its third or fourth skin, which is likewiſe to be caſt off ſoon after.

V. The Louſe, having attained the full term of its increaſe; in which period we have conſidered it as a Nymph animal; becauſe it is then in the laſt skin that it will caſt, and indeed we find ſome inſects in this firſt order, which are ſtill ſomewhat changed about the time of caſting their laſt skin; which is ſufficiently evident, among other examples, in the longipede or long-legged Spider; the legs of which grow much longer, at the time it is caſting its laſt skin. After this is caſt, the inſects of this firſt order grow no more, nor are they any ways changed; as may be more eaſily underſtood from the figures of the ſubſequent examples of the four orders, under the ſame numbers V and VI.

VI. The Louſe, having attained its perfect maturity and full growth, ſo that is now fit for generation, and is arrived to the ſtate of puberty. Fig. III. repreſents it magnified by the microſcope.

Fig. I.

The Nit or egg of the Louſe delineated with a microſcope.

a. An oviform border or extremity, which ſurrounds the Nit's head; within which are ſeen certain ſmall cups, like uvulæ, of no exact or determinate figure. Theſe little cups are ſomewhat bent, and they again ſwell in the middle, as it were into a whitiſh top. It is obſerved alſo that theſe little cups do not intirely fill the inward parts of the border or circle that ſurrounds the head.

bb. Two tender little ſwellings or pimples, wherein the Louſe's eyes, whilſt its limbs are yet moiſt and ſoft, are ſituated. Theſe eyes grow inſenſibly browner, and become viſible through the ſkin, and at length grow entirely black.

c. A certain white pellucid little part, ſituated in the middle of the Nit, which we have often obſerved to beat regularly like the heart; and this is the little part repreſented by the letter *b.* in figure VI. and called by us the pancreas, as it moves up and down with the ſtomach.

Fig

Fig. II.

Th e egg-ſhell, or empty Nit, and the firſt skin caſt by the Louſe.

a. The border or extremity of the head burſt aſunder with its little cups, and driven back by the Louſe creeping out at the upper end.

b. The other part of the caſt and empty ſkin of the Nit, from which the border of the head was ſeparated; ſo that it reſembles an empty tankard, having its aperculum or cover taken off.

Fig. III.

The Louſe lying on its belly, and magnified with the microſcope.

On its head is ſeen a ſhining ſkin, together with ſome little holes and diviſions. On the breaſt or back is an elegant delineation of a ſhield, which is painted in the middle; and the glittering ſkin is alſo obſerved to be here variegated with little holes. The legs, which are fixed to the breaſt, are full of little ſwellings or pimples, like ſhagreen ſkin, but they are loſt by degrees towards the end of the legs. There are many hairs betweeen the claws of the legs. It hath been diſcovered by the microſcope, that at the extremity of the abdomen, the skin likewiſe appears painted and rugged, with little grains like ſhagreen as before mentioned; but I have at length diſcovered with the beſt microſcope, that the skin really conſiſts of irregular ſquares, globules, &c.

Of the Arboreſcent Water Flea *.

After the Louſe I have likewiſe in this firſt order, placed the Arboreſcent Flea, whereof I now intend to treat particularly. This inſect, which I here delineate larger than the life, Tab. XXXI. fig. I. *a.* is the ſame that in fig. II. I have repreſented alſo larger, yet in a ſide view. In this, beſides the outward form of the body, which is ſquare as it were, I ſhew an eye in one ſide of the head, fig. II. *a.* and under it a ſharp beak *c.* On the breaſt are ſeen arms, divided into branches *bb* like the boughs of trees; and in the abdomen there is a tranſparent ſubſtance, with the legs and tail; and in the hinder part of the body, its legs appear placed as it were on the middle of the back.

But if this animal be repreſented in the form wherein it ſhews itſelf to the naked ſight, you would ſay it had only one eye; for the eyes, by reaſon of the ſmallneſs of the head, ſeem to be joined to each other. They are ſituated in the beak of this inſect, and this beak is likewiſe very ſmall and ſharp-pointed. The ſtructure of the eye is ſeen by the microſcope, to be reticulated, or made like a net, ſuch as we ſee in the eyes of other inſects, and the beak is not only ſmall and ſharp, but alſo tranſparent: and it ſeems probable, that this little animal ſucks in its food, by the help of this little part, as is uſual with other aquatic inſects, which feed themſelves with their hollow beak, or tubular aculeus or ſucker.

Of all the parts of this animal, its branching arms, and the motion it makes with them in the water, deſerve out greateſt attention. They ariſe undivided from two, as it were, ſimple trunks, which, like the ſhoulder bones, ſpring from the ſhoulder blades, and are each divided into two branches; each of theſe is again ſubdivided into three different joints. At the firſt and ſecond joint, reckoning from the ſingle trunk, there ariſe on each ſide a little branch, almoſt like a hair; and at the third or extreme joint, three ſuch buds or ſhootings are placed, which alſo ſeem to be again divided into other joints.

But though theſe arms are very remarkable, and worthy of conſideration, the motion produced with them by this inſect deſerve yet greater notice. For this is threefold; firſt, the little creature can, with their aſſiſtance, move in a ſtraight line; whilſt it conſtantly waves its ramified arms, as a bird its wings in the air, ſometimes upward, ſometimes downward, and ſometimes on one ſide, and all the while moves forward in a ſtraight line.

A ſecond motion is like that of the ſparrow, for as theſe, by expanding and again contracting their wings, paſs with an uneven motion through the air, and ſometimes deſcend, and immediately after are carried aloft again; ſo this little animal, by ſtriking the water now and then with its branching arms, obtains a like unequal motion, and ſometimes dives as it were to the bottom, and again riſes up to the ſurface. Theſe ariſe from the alternate ceaſing and repetition of the motion; the animal by this means moving in a different manner. Since, therefore, the motion of this little creature is not at that time very irregular, it happens that it is continually ſeen to jump in the water, its head always tending towards the ſurface, and its tail ſtretched downward.

I cannot find a more proper example of the third kind of motion in this animal, than the whirling or turning about of that kind of pidgeons, which, from this whirling or gyration of the body, are called tumblers. For as theſe tumblers, when whirled about in the air like a ball, ſeem for a time to be deprived of their motion, and fall as it were downward towards the earth; ſo this little creature, inclining its head down into the water, and at the ſame time raiſing the hinder part of its body upwards, moves itſelf as it were in a circle, without any interruption in the motion of its arms, which it uſes upon this occaſion as oars. Hence it happens, that the parts of its body, though in perpetual motion, and naturally always ſunk into the water, are ſometimes ſeen under and ſometimes above it; which is a very pleaſant ſight,

* This inſect is frequent with us in ſhallow and ſtanding waters, as in the ditches at Tothill-fields.

fight, and may be compared to the turning of a wheel about the axle-tree of a chariot.

In regard, therefore, of the motions before explained, by which this little animal feems to approach rather to the nature of Fleas than Lice; and on account of its wonderful arms, which are made like the boughs of a tree, I think it may be properly called, as I have named it, the Arborefcent Flea.

The ftructure of this infect's belly likewife deferves as much confideration as its breaft and arms: if we view it on the outfide, it will feem to be of a rhomboidal form; but in reality, the part which refembles the belly, is nothing more than a tranfparent skin full of fcales or fhells, fig. II, *d*, which is joined together in the back or pofterior part of the body, but in the fore part is divided into two fegments which open from each other; and thus it forms, as it were, a little open cafement, through which the animal can move his real belly and tail in and out. Therefore this rhomboidal skin which covers the infect, is only its fhell, through which its real body is feen, as this fhell is tranfparent. This fo far agrees with the teftaceous animals; but it differs from them widely with refpect to its diftinctly vifible motions, which it has with the abdomen and tail. I have often obferved that it ftretched out its tail through the opening in its skin or fhell beforementioned, and pulled it in again. This fubftance, or the body and tail, are waved and turned round like the letter S; in the middle is feen a fmall tranfparent inteftine, and in the fore part are feen feet which are tranfparent, formed almoft in the fame manner as the articulated briftles in Shrimps, and having the like, as it were, tremulous or jumping motion, wherewith this animal, as well as the Shrimp, can change its place; though this office is performed in general by its arms, to which, however, the legs feem to be fomewhat affiftant. The extremity of the tail is divided into two fharp and ftiff briftly hairs *f*, on which, at a little diftance, grow two other fimilar ones. The eggs *h* are placed on the back of the body, which I affirm as certain for this reafon, becaufe, foon after this infect hath caft them out, very fmall whitifh infects are feen fwimming in the water, which are of the fame nature with the full grown ones, nor do they undergo any other change, except that they grow bigger; as I have fhewn to happen to Lice, in the example of the changes of the firft order.

In figure III I fhew all the parts hitherto defcribed, except only the eggs which are caft out, with this difference, that a little of the fore part of the body, which was before reprefented laterally, is here delineated; fo that the motion of the inward body and tail through the rhomboidal fhell, or skin, may be feen the more exactly. The feet alfo may, by this means, be feen more plainly, being here ftretched out beyond one fide of the skin; which I fhall make more clear, and explain more particularly hereafter by letters.

The colour of this infect inclines fomewhat to red in the full grown; and is like that of beef, which has been fome time fteeped in water. The outward ftructure of the skin that covers it agrees, in fome meafure, with the reticulated and checquered fhell skin of the fcaly fifh; though I could hitherto fee no fcales in it, having never viewed it through microfcopes, which, in the moft powerful manner, magnify the bulk of objects: but it is tranfparent like the skin of the Shrimp, or as the fhells of very fmall Mufcles and young Cockles. The extreme part of the branching arms is like Hen's feet, but their divifions are not fo diftinct.

I have frequently the infect I have been hitherto defcribing, in cifterns of rain water, when no rain hath fallen for a long time; but when thefe infects have plenty of rain, they can fcarcely be feen, becaufe they divide themfelves here and there to every quarter. I have found them likewife in running water, and in moorifh or fenny ditches, wherever any of the clear water has ftagnated on the fediment at the bottom. They fometimes remain feveral days on the furface of the water, and fometimes are feen at the bottom only; but we feldom or never fee them at reft. They change their skin like Lice, and the caft skin refembles the infect itfelf fo exactly, that you would fay, you faw it alive. I keep by me fome skins of this fort, which are very curious.

I remember when I was in France, in the foreft of Vincennes, that I faw fo great a number of thefe infects in a watering-place for horfes, that the water appeared as if changed into blood; which, indeed, terrified me at firft, but it afterwards gave me an opportunity of inveftigating the nature of thefe infects more accurately, and made me cautious not to pafs too rafh a judgment on things that are obvious and familiar to us; for this leads us into innumerable errors and prejudices. It is not impoffible that thofe who affirm that bloody rain has fallen, have been deceived in the fame manner. Is it not poffible, that fuch red drops might iffue from infects, at the time they come frefh from the Nymphs, which diftil a bloody fluid? This feems to happen, efpecially when fuch infects are more than ordinarily multiplied in any particular year, as we often experience in the Butterflies, Flies, Gnats, and others.

The celebrated Florence Schuyl, who was profeffor of phyfic in the univerfity of Leyden, long after this incident communicated to me the like obfervation concerning bloody rains. He informed me, that being once intent on his ftudy, he heard a noife, of which, as it increafed by degrees, he was defirous to know the caufe; and that he was foon fatisfied in this particular, for that one of the maid-fervants ran up to him, and told him, in an interrupted fobbing tone of voice, that the waters of Leyden were turned into blood. Upon this, he went directly in a ſmall bark to the places he had mentioned, put ſome of the bloody water into a glaſs, and, upon viewing it carefully, obſerved that it was common water, and abounded with little red animals. Thus his ſudden fright was changed into a laſting admiration. Before I treat of other matters, I ſhall diſcloſe a method, to the diligent ſearchers into nature, by which I have diſcovered theſe and ſuch like aquatic inſects in water, which, when found, may be examined more accurately.

To find ſingle inſects in water, I know nothing more proper than the glaſs veſſel commonly called an urinal; for if its empty belly be ſomewhat narrow, the ſmalleſt animal ſwimming in it muſt be ſeen by us, ſince the water itſelf contained in it ſupplies the place of a microſcope. As the glaſs, therefore, is wider or narrower, ſo we ſee the little animal repreſented leſs or greater. But it muſt be obſerved, that this augmentation is not viſible, except only when the animal ſwims on the oppoſite ſide of the glaſs. When the inſects are once obtained, they may be removed into ſmaller glaſs bottles, wherein the parts may be ſeen much more diſtinctly: nay, the microſcope, conſiſting of only one convex glaſs, may upon this occaſion be uſed to advantage. Beſides theſe, we have likewiſe other helps to magnify theſe little creatures: we have cauſed very ſmall round bowls to be made of glaſs with diviſions, in which we have, by the help of a microſcope, viewed the inſect, having only a little water, to the utmoſt advantage; and gained a very diſtinct knowledge of all its parts. It may likewiſe be very conveniently examined by the microſcope, if it be placed in a ſmall drop of water, dropped upon white paper; provided one takes care to avoid the brightneſs produced by the water. If the inſect ſhould happen not to be diſtinctly ſeen upon a white ground, we may change the white into yellow, green, blue, or any other colour: we have, for this purpoſe, put our little glaſs bowls before mentioned, into a cake or compoſition of ſtarch and blue, into ſoot, vermillion, and other paints; and by this means our endeavours have been crowned with a fortunate event. Since, therefore, the method we have been hitherto explaining, has been very uſeful to ourſelves in diſcovering a great many water inſects, and viewing their parts with the help of a microſcope, we no longer deſire to conceal it, but communicate it for the ſervice of the public. To this we ſhall add, that among all the kinds of microſcopes which have been invented, none is better than that which has only one lens. But ſince we owe the benefit of this inſtrument or contrivance to that very great and incomparable mathematician, Mr. John Hudden, ſenator of the city of Amſterdam, we eſteem it our duty to do this renowned gentleman honour; and to give him public thanks for the favour he has done us in this reſpect.

A particular treatiſe on the Scorpion, which likewiſe belongs to the firſt claſs or order of natural changes.

NEXT in order under this head, come the Scorpions, which are viviparous, according to the obſervation of Dr. Francis Redi; his words are theſe: "The thoughts "of the great Ariſtotle were juſt, who is of "opinion that Scorpions are generated by the "conjunction of the male and female; the "Scorpion not laying eggs, like other inſects, "but bringing forth little Scorpions alive and "perfect in their ſpecies: and of this opinion "are alſo Pliny, Lib. II. Cap. xxv. and Ælian, "Lib. VI. Cap. xx; and the ſame thing has "been accurately obſerved by Thomas Furenius, and by the very learned John Rhodius, "in their medical obſervations.

"As, therefore, I had nothing to follow or "avoid, I began at once my experiments; "and having brought a large quantity of Scorpions from the mountains of Piſtoiæ, in "Tuſcany, I ſelected ſome of the females, "which, by their ſize and roughneſs, are "eaſily diſtinguiſhed from the males, and on "the 20th of July put them in ſeparate glaſs "veſſels, and kept them without food; ſome "of them died before they brought forth their "young. But one of thoſe on the 5th of "Auguſt brought forth, not eleven, as Pliny "and Ariſtotle have imagined, but thirty-eight "Scorpions, well ſhaped and of a milk-white "colour, which every day changed more and "more into a dark ruſty hue. Another female in a different veſſel brought forth "twenty-ſeven of the ſame colour, on the 6th "of the ſame month; and the latter, as well "as the former, ſeemed fixed, as it were, to "the back and belly of the female. On the "19th all theſe young ones were living, but "afterwards ſome of them died daily, ſo "that I loſt all ſoon after, except two which "ſurvived until the 24th of Auguſt, and "then they died alſo.

"In the mean time, I had a mind to ſee "how theſe inſects were placed in the parent's womb before their birth. Having, "therefore, opened ſome of them, I found "different numbers, yet never leſs than "twenty-ſix, nor more than forty; all which "hung on an oblong thread, and were covered "with a very fine and delicate membrane, "in which one Scorpion was very clearly "diſtinguiſhed from another, by a certain partition reſembling a fine film." Thus far Dr. Redi, in Exp. Circa Gener. Inſect. But the deſcription given by him does not at all ſatisfy

ſatisfy me, ſince his deſcription of the uterus and its oviducts is not ſufficiently exact; nor does he take any notice of the place where the oviducts are connected with the uterus, and form one common excretory duct. I ſhould likewiſe be glad that the extremities of the oviducts had been examined by him, and that he had deſcribed the rudiments of the eggs contained in them. He ſhould have told us, what that oblong thread is of which he makes mention, and which was doubtleſs one of the oviducts. The membrane, likewiſe, which ſeparated the Scorpions from one another in the oviduct, could be no other than the membrane which covers the fœtus of this inſect, and ought indeed to be called the proper egg of the Scorpions. It is probable that he found this egg in the extremities of two oviducts; though his words import, that there was only one oviduct, which he calls an oblong thread; which ſeems to me ſcarce probable, ſince we are taught the contrary from the analogy there is between the uterus and oviducts in all inſects. And when he makes mention of a partition, which, like a very fine film, ſeparated the young Scorpions, he ſeems in that place to divide an oviduct: but the author, ingenious as he is, ſpeaks here ſo perplexedly and obſcurely, that it ſeems as if he intended to propoſe an enigma for ſome future Ædipus.

I am perfectly ſatisfied that Scorpions, which I have never known to be refered to any order, ought to be inſerted in the firſt of my plan, with this difference only, that they are brought forth alive; whereas the Louſe only lays eggs or nits, from which its young afterwards proceed. The Scorpion is, therefore, like the viviparous Snail, which excludes its eggs in its own body, and afterwards brings forth its young alive, but at different times and intervals; whereas the Scorpion has thirty-eight young ones together at one birth, which afterwards, by degrees, increaſe and grow bigger.

As the true figure of the Scorpion has not yet been given by any perſon, that I know of, I ſhall here repreſent their natural ſhape. And that I may the more accurately execute this, I ſhall divide the Scorpion into the head, breaſt, and belly. The Scorpion's head ſeems jointed, as it were, to the breaſt, as I have found in all the dried Scorpions that I have ſeen hitherto. In the middle of the breaſt, or in the head connected to it, are two eyes; and a little further towards the fore parts, there is likewiſe another pair of eyes, placed as it were in the forepart of the head. Under theſe are obſerved two ſhort arms, forceps or pinchers, Tab. III. fig. 1. *a*, which the Scorpion, doubtleſs, makes the ſame uſe of as others animals do of their teeth, and with which it breaks its food, and thruſts it into its mouth. Theſe four ſhort forceps, and the four eyes above them, have never, to the beſt of my knowledge, been obſerved or deſcribed by any perſon, but hitherto entirely neglected. The Scorpion can at pleaſure put back theſe forceps or teeth into its mouth, ſo that none of them may be ſeen.

Under the breaſt are eight articulated legs *bb*, each divided into ſix joints, the two hindmoſt of which are each provided with two crooked claws, and the legs have here and there ſome hairs. At the foremoſt extremity of the head are two flagella or whips, or crooked arms like pincers *cc*, compoſed of four joints, the outmoſt whereof is fortified, as it were, with a thumb, by the contraction of which the forceps is formed. This joint is thick and ſtrong, and contains ſtout muſcles, as we likewiſe obſerve in the claws of Lobſters. The belly is divided into ſeven little rings *d*, from the loweſt of which ariſes a tail compoſed of ſix joints, which are briſtly and formed like little globes *e*; the laſt of theſe joints is armed with an aculeus *f*, or ſting.

Dr. Redi ſays, he ſaw that the Scorpion diſcharged a very ſmall drop of water through the ſting in its tail; which I ſhould eaſily believe, ſince the poiſon infuſed by Bees through their ſting into a wound, likewiſe conſiſts of a very clear liquor. And this makes me ſuſpect that the external ſting of the Scorpion, in like manner as in Bees, is no more than the ſheath, wherein the true aculeus or ſting is concealed. I once undertook to examine this matter in a dried Scorpion, but ſince the loweſt ring of the tail, from which the ſting hangs, became hard as a horn by drying; I could not accompliſh my deſign according to my wiſhes. I obſerved therein, however, two ſmall tubes, which ſeemed to end in a ſacculus or little bag, that carried, I ſuppoſe, the poiſon, and had on the fore part two aculei or ſtings; but all theſe things were ſo confuſed, that I would not preſume to affirm any thing certain concerning them. If I had had the Scorpion alive at that time, and ready at my hand, it would have been very eaſy to have clearly diſcovered this matter.

In another kind of Scorpion, fig. II. I ſaw that the two foremoſt crooked arms *aa* differed very much from thoſe which I have before deſcribed; for the forceps were, in compariſon to the former, very ſmall, and ended in a ſharp point. On the fore part of the head were, like theſe, two forceps or teeth beforementioned; and above theſe on either ſide were three eyes, ſo that there were ſix in all. In all other particulars it was like the former Scorpion; unleſs that in the reſt of its limbs there was here and there ſome very ſlight difference, as is ſeen in the figure. This little Scorpion was very delicate, and it may be eaſily known, from the ſmallneſs of the forceps, that this kind have leſs ſtrength than thoſe of the former; but then the longer they are, the more conveniently they can take hold of their food.

As the larger the animals are, we can attain to the more accurate knowledge of them; I ſhall now repreſent again, in a very large Scorpion, all the parts which I have deſcribed in the

the two former; particularly thofe two briftly teeth, or foremoft forceps, fig. III. *a*, are in this feen very clearly; as alfo its two foremoft eyes *b*, of which there are fix on each fide of the head, fome gradually lefs than others. In the middle of the head, where it is connected with the breaft, are two eyes, which may be diftinguifhed eafieft of all, and which have therefore been alfo obferved by all authors; who, notwithftanding, feem to take no notice of the twelve other eyes. The head, breaft, belly, tail and fting, together with the legs, forceps, hair and claws, are likewife much more confpicuous in this than in the two former. The fix joints of the legs are exactly in this the fame as they are in the fmaller Scorpions. The crooked arms of this alfo confift of four joints, and carry forceps of an horrible bignefs; but there is a peculiar difference in the tail, fince it is divided into fix joints in fmall Scorpions, and in this had only three: I doubt, however, whether this be fo by nature, fince I think I could perceive that the tail had been broken, and glued on again before it came to me; but all the articulations were not joined together. The colour of this Scorpion is very black, like pitch.

I have another Scorpion almoft the fame fize with the laft, having a tail compofed of five joints, whereof I have the fame fufpicion that I had of the former, that is, that it is not natural to it; for I am thoroughly perfuaded, that in all kinds of Serpents the tail confifts of fix joints. The latter was brought me from America, but the former very large one, the figure whereof I have given before, from the Eaft-Indies. The figure of the American Scorpion is like that from the Eaft-Indies. Doctor Padbrugge, governor of the Molucca iflands, has this year fent me a drawing of a peculiar Scorpion, which was of a light red, but is now grown of a blue or sky-colour; its tail is compofed of fix joints, and in other particulars it differs not from the very large one which I have reprefented, only that it is not half fo large.

In Holland there is found a certain fpecies of Scorpions, which are very fmall, and no bigger than a Bug; they likewife refemble it in the hinder part of the body, which is divided into eleven fmall rings, and wants a tail. They have fix legs, each of which confifts of four joints. The breaft, which is connected with the legs, is diftinct from the head; the forepart of which has a pointed beak covered with hair. They have likewife many eyes, which are diftributed over the fides of the head: the crooked arms are placed before the eyes, and fpring from the head like the antennæ or horns in Butterflies, being compofed of four joints, including the forceps, the ftructure whereof is the fame with that of the Scorpion's before reprefented in fig. II. All thefe parts have on them fmall, briftly hairs, and are of the fame colour with the common Scorpions of Germany and Italy. The arms before-mentioned are very long and large, in comparifon of the fize of this animal; nor can there be a more agreeable fight than the remarkable motions it makes with their affiftance, when it changes place, and moves itfelf like a land Crab. This infect is often found in benches, chefts and coffers, that have not been cleaned for a long time, where, in my opinion, it maintains itfelf on thofe little animals which there multiply in the duft, and of which there are many kinds; feizing them, I fuppofe, with its forceps, and fwallowing them for food. I have likewife found this infect in fcarlet cloth, which had been kept long in a cheft. I have nothing farther to fay of this animal; I have defcribed it according to the parts that I have found in it, when fixed on a needle and dried.

The natural hiftory of the covered Snail, illuftrated by accurate drawings.

The INTRODUCTION.

THOUGH the Snail was reckoned by the Jews among unclean animals, which they were forbid to ufe as food, they did not fcruple the application of it to other purpofes. The royal pfalmift borrows a moral fimile from it, and prays, that the wicked may "confume away like a Snail;" and, however impure and flimy, it muft notwithftanding claim the confideration of thofe, who are defirous of being acquinted with the wonderful works of the creation.

There are many chriftian nations who place Snails amongft the dainties of the fecond courfe, but they are only thofe of a particular kind. In Holland no Snail is ufed for this purpofe, but the valved kind found in the fea or other waters, the mufcles being of a pretty tenacious fubftance. The way of eating them, is boiled and well feafoned with falt; and no part of them taftes ftrong except the liver.

Other nations, as the Italians, Germans and French, eat the garden Snail, efpecially at the feafon, that, after a faft of feveral months, it has cleanfed itfelf of all impurities; for during this period, there grows upon the mouth of the fhell a covering, compofed of a fubftance not unlike plafter, which hinders the earth or any kind of dirt from getting into it. In this manner this kind of Snail paffes more than feven months, from autumn to fpring, without any motion or food.

The fhells, blood, and opercula of the Snail kind have likewife their ufes in medicine. Amongft the opercula of Snails, that called Blatta chiefly deferves our attention; it belongs to the Murex or purple Snail, and as it comes

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to us from Byzantium, a town in Africa, where the art of dying purple formerly flouriſhed, it has obtained the name of the byzantine Blatta. However, this word Blatta is now made uſe of, to ſignify the opercula of all kinds of ſhell fiſh without diſtinction, though there are ſo many and ſo great differences in this ſingle part, that an entire treatiſe might be wrote on it alone; and certainly ſuch a treatiſe might be very uſeful, as well as entertaining.

My intention, at preſent, is to treat of the Snail, known by the name of the vine or covered Snail, and deſcribe its manner of living and propagating its ſpecies, which I have made myſelf acquainted with by a very exact diſſection: by means of this, I ſhall, among other things, prove, that in this creature both the brain and ſpinal marrow have their proper muſcles; and ſhall likewiſe ſhew in what manner this, in appearance, ſo contemptible a creature is provided, by the greateſt of all wonders, with eyes, that may not only be diſtinctly known for ſuch, but even felt; and how it is at once both male and female in the ſame body; as alſo how it proceeds by generation, from an egg, like other animals. Hence will appear the folly of that common opinion, which makes them proceed from ſlime or mud, a fancy which could only find place in the empty heads of thoſe, who, inſtead of ſtudying God's wiſdom, power, and goodneſs in his works, ſpend their lives in reading books which miſrepreſent them, or at beſt, only repreſent them at ſecond hand, ſtealing from one another.

Hence alſo it will appear, that this animal is to be ranked in the firſt ſpecies of my four natural orders of mutations, in which inſects proceed immediately from an egg, without paſſing through any intermediate ſtate, as I ſufficiently have deſcribed in the general hiſtory of inſects.

I ſhall here deſcribe that kind of Snail, to which the inhabitants of Brabant and Flanders have given the Spaniſh name of Caracol. It would be an endleſs task to treat particularly of every ſpecies of Snail, Cockle, Periwinkle, and other creatures of this kind, that are found with or without ſhells, though all belong to the ſubject we have in hand; ſince for this purpoſe, it would be requiſite to call all nature together, and ſearch the ſeas and rivers, and every part of the earth.

Nevertheleſs, I ſhall take notice, in the proper place, of what I have occaſionally ſeen and obſerved in other kinds of Snails; ſuch as the houſe Snail, which has a little ſtone for its ſternum; likewiſe the common Snail, which we meet with in path-ways, without any ſhell like the firſt. I ſhall alſo ſay ſomething of the garden Snail, the freſh-water Snail, the Crab, or ſalt-water Snail, the mother of pearl, and ſome other kinds of Snails, which I have had opportunities of ſeeing and examining. Some of theſe live upon trees, and there are others, but very ſcarce, which have the ſpiral line deſcribed by thin ſhells turned the contrary way.

C H A P. I.

Of the ſhell and ſoft part of the Snail in general, and particularly of the four horns which ſpring from the upper part of its head, and of the eyes that appear in them, with a deſcription of the conſtruction and motion of thoſe parts.

BEFORE I begin to ſpeak of the body, or ſoft part of this creature, I ſhall ſay ſomething of the ſhell or hard part: this is prepoſterouſly called its houſe, if we take that word in its proper and common ſignification, ſeeing it is the very skin of the Snail, without which it would be as impoſſible for it to live, as for a Lobſter, or a man who had been flayed, or a tortoiſe drawn out of its covering. This cruſt therefore ought to be conſidered as the bone of the Snail, in which all its muſcles are inſerted, as the muſcles of quadrupedes are fixed in theirs. This is very obſervable in ſea Muſcles, as I ſhall in its proper place accurately demonſtrate.

To paſs now to the ſoft part of the Snail's body; it is to be obſerved, that what appears of this part, when it moves forward with its ſhell, is about three inches and a half long, and almoſt two inches broad. In the fore part of its head appear four horns, two greater, Tab. IV. fig. 1. *aa*, and two leſſer *bb*, without any ſpots at their extremities. Under theſe horns we may perceive its external lips, and its mouth *c*, and between the firſt and the ſecond horn is the perforation *d*, from which iſſue the organs of generation, when they ſwell up for that purpoſe; at other times this hole is ſo nicely cloſed as not to be diſcernible. Behind, towards the edge of the ſhell, is a thick border or lip, which on every ſide, both within and without, adheres firmly to the external edge, and internal ſurface of the ſhell; but this part is like the skin, which in naked Snails hangs under the fore part of the body; and under which, as under a veil, they hide their head and horns when they are touched. In this lip or border there are on the right ſide two openings, one of which *f* ſerves for the creature to diſcharge its excrements, and the other *g* to breathe. In the body there evidently appear thoſe flat and broad fringes *hhh*, by the help of of which, chiefly, the creature moves: they confift of very ftrong mufcles, for which reafon I call them the Snail's feet, as refembling in fome meafure the feet of Bats and Ducks; whofe claws are connected to each other by a membrane. This fort is covered underneath with a thin skin, and the upper part is bent, with a number of glandulous fpots or warts of different forms, amongft which there run a great many veffels: but I fhall hereafter fpeak more at large of thefe particulars.

Fig. II. If after having taken the foregoing furvey, we entirely ftrip off its fhell, or rather ftony bone *c*, from the tender part of its body, we fhall find the flefhy part which heretofore lay hid, is exactly of the fame fpiral form and fhape, fig. I. *k*, with the fhell that covered it, but then it is perfectly tender, without the leaft fenfible hardnefs.

Here all the inteftines, in a manner, appear through the extremely thin and tranfparent membranes of the body, which are all over fpread thick with veffels: for the hard furface being once removed, the leaft puncture made in the skin that remains, is followed by the effufion of the Snail's blood, like a mucous humour, of a pale purple colour. This can only happen from the body's being all over pervaded by a great number of veins and arteries, fo that on dexteroufly clipping the fmalleft portion of its foot or border, you may perceive little ftreams of blood iffuing from the wound.

To remove the fhell or bone of the Snail, it is beft to ufe a pair of flat pincers, by means of which the fhell or bone may be gradually broken and torn away, till we come to the part where the mufcles of the body are inferted into it. Tab. VI. fig. II. *a*. The tendons of thefe mufcles muft afterwards be feparated by a flat fpatula; we muft then proceed as we begun, by gradually breaking and tearing away the remains of the fhell, till there are but one or two twifts left; out of which the little tail in which the body terminates may be then drawn without any difficulty.

All the four horns, Tab. IV. fig. I. *aa*, *bb*, agree with the upper part of the skin of the body, in being adorned with little glandulous unequal grains, fig. V. *eee*, like fo many warts; but thofe on the horns appear the fmalleft and moft exquifitely divided. The horns themfelves, when viewed through a microfcope, look as if they confifted of a greenifh tranfparent fubftance, like veal gelly, through which appear fome whitifh fpots; thefe I take to be the glands made ufe of by the creature for the fecretion of its flimy or mucous humour. This flimy matter ferves to moiften conftantly not only the whole body, but the horns; and in my opinion, the conftant moiftening of the latter is extremely neceffary, confidering how often and how fwiftly the Snail is obliged to ftretch them out and pull them back again; an exercife which, without fuch a contrivance to keep them flippery, could never be performed.

Though all four horns are very remarkable, the two uppermoft and longeft deferve our particular confideration, both on account of the power of motion given them by the fupreme architect, which is very fingular, and exceeds all human art; but more efpecially becaufe they have evident eyes, appearing like two blackifh points, in their extreme ends: they at times ftretch thefe eyes in a manner not to be defcribed, yet by a regular motion, out of the body; and fometimes they hide them by a very fwift contraction in the cavity of the abdomen.

I know, indeed, that many who have laboured to inveftigate the nature of thefe little creatures from fpeculation only, have given the name of eyes to thefe blackifh fpots vifible in the tips of the horns; but their own fancy has afterwards made thofe very perfons change their opinion, when they faw that the Snail ftruck thofe horns almoft againft every object, and that they fhewed no figns of quicknefs of fight. But the knowledge of nature cannot be acquired by reafoning only, for unlefs we make experience go hand in hand with reafoning, we fhall err all our lives*. I fhall therefore lay afide all conjecture, and defcribe thefe eyes and their membranes, humours, mufcles and nerves, as I have feen them, that the hidden, and for ever to be celebrated miracles of God may be made manifeft to all lovers of his works, who have not opportunity to fearch themfelves into thefe matters.

Thofe who thirft moft after true knowledge, are with reafon afraid, left the poifon of falfities fhould be offered to them, inftead of the food they feek of true knowledge.

To methodize and fet all thefe things in a clearer light, I have fubjoined the figures of all thefe parts immediately after their defcription. The firft thing that deferves notice in the examination of the upper horns, is their extremity, in which three particular little parts are obfervable. The firft of thefe little parts is placed in the middle, and is a very black fpot, Tab. IV. fig. I. *aa*. This is the real eye of the Snail, fig. V. *a*. The fecond is the optic nerve of this eye *b*, which, by a certain production like a little globe, fwells and appears through the skin. The third, conftitutes the extreme end of the mufcle of the eye *c*, whereby the external skin, which is equally extended thereon, is firft bent in or drawn back, when the Snail endeavours to draw its eyes into its body. This motion always begins about that part or divifion of the eye *d*, which lies in the middle between the mufcle and its nerve. But as the apex or end of this mufcle is fomewhat more prominent than the eye or its mufcle, it therefore firft receives all injuries, whenever the creature happens to ftrike its little horn

* Perrault, after many obfervations, expreffed his doubts, whether Snails had really any eyes or not; and Dr. Brown has placed his opinion of their having any among vulgar errors: but this author's obfervations are confirmed by many fubfequent examinations; and very lately, Dr. Peterfield has fhewn, they are to be feen very diftinctly. His account is publifhed in the Edinburgh effays.

againſt any thing. Thus the eye is defended and kept ſafe. Moreover, theſe extreme ends of the horns are ſtretched ſmooth, and have a bright ſurface, ſomewhat red, and full of prominences or little warts; but the glands *eee* appear to be ſituated a little lower, between the globular production of the horn, and they are likewiſe divided on the inſide by very ſmall whitiſh points. The furrows or ridges viſible at the bottom between theſe glands, are the veſſels which carry the glutinous humour to all theſe parts, and again bring it back from them. And that theſe muſcles and nerves may lie convenient, the whole horn is hollow *f* on the inſide; ſo that if it be diſſected tranſverſely, the extremities of theſe parts preſent themſelves on the inſide.

To have a more clear idea of this matter, it is neceſſary to open the Snail, for which purpoſe you muſt have a ſmall and ſharp-pointed pair of ſciſſors; one of the points of theſe ſhould have a little ball made of ſealing wax fixed on it, to prevent the inward parts from being wounded. Then, after opening the middle of the back, the body muſt be cut to the verge of the Snail, Tab. IV. fig. I. *e*; after this direct the ſciſſors forward, and diſſect the skin as far as the fore part of the head, between the two upper horns. The diſſection being thus made, the firſt thing to be met with, immediately under the skin, is a certain muſcular delicate membrane, which is very thin and fine; it covers all the inward parts, and is provided, here and there, with muſcular fibres, which run acroſs from one ſide of the body to the other, and are inſerted into the ſides of the ſhell; you may alſo then ſee the ſtomach, organs of generation, and the like. Afterwards the brain, which lies on the upper part of the ſtomach and over the gullet, preſents itſelf; and immediately afterwards, the horns themſelves drawn back, with their muſcles in the abdomen.

Having thus briefly touched upon theſe matters, I ſhall proceed to explain and deſcribe by figures, how theſe four horns, Tab. IV. fig. VI. 1, 2, 3, 4, are circumſtanced, when they are drawn into the body, and their inward ſides are turned out; for which purpoſe, each of the horns has its proper muſcle. The two upper and largeſt horns have their particular muſcles *aa*, each of which is connected by its proper tendon to the two muſcles which move the middle of the body, and theſe are afterwards with them inſerted by their tendons into the ſpiral part or folding of the ſhell, Tab. VI. fig. II. *hh*, *nn*, *a*.

The two lower horns, not being of ſuch importance as the upper ones, are provided with two ſmaller muſcles *bb*, which ariſe from the larger *cc*, and draw in the lips of the ſnail. This is likewiſe repreſented in Tab. VI. fig. II. *ll*, *mm*.

The manner in which the horns are twined and ſtretched out of the body, is a much more difficult thing to be deſcribed; though I think, indeed, that the inward coat, or muſcular part of the horn, performs that office, with the aſſiſtance of ſome other ſmaller and adjacent muſcles, as well as ſome ſtronger ones, whereby the fore part of the head, and the skin of the ſnail is moved towards the outſide. The true action, which I think the inward annular muſcles have, ſeems to conſiſt in this, that ſome of them are ſucceſſively contracted and ſtiffened after others, by which means the horn is continually rolling out, and one ſmall portion of it is puſhed after the other; to this action, the periſtaltick motion of the inteſtines, as far as the latter is performed by the contraction of the annular muſcles, bears ſome, though perhaps a diſtant, reſemblance.

But the optic nerves deſerve more conſideration, both on account of their texture and their motion. Before I deſcribe theſe, I ſhall take occaſion to ſay ſomething of the brain, from which they ariſe. The brain *d* conſiſts of two globular little parts, and, by this property, is divided into two portions, as it is in man. The firſt is placed in the head; but becauſe this, as well as all the other parts of the ſnail, is, in a wonderful manner, moved ſometimes backward and ſometimes forward, no fixed or certain place can be aſſigned to it. I therefore ſhew both the brain and optic nerves in the ſituation wherein I have delineated them. The hinder part of the brain, is drawn in Tab. IV. fig. VI. *e*, to the skin of the ſnail's head, and is ſituated a little above its ſhining tooth *f*; for the brain, together with all the parts of the gullet and mouth *g*, and alſo the ſtomach and ſalival veſſels *ii* are driven to this depth into the body, by the ſtrength of a muſcle appointed for that purpoſe; but when all the parts are again rolled or turned out, we may then ſay, the brain is placed at the fore part of the head. Hence it is evident, that the motion of the brain in this creature ought to be obſerved as a thing worthy of the higheſt admiration; wherein both the wiſdom and infinite power of the almighty are manifeſt: ſince he has been pleaſed to render this part, which in man and other animals he made immoveable, by encloſing it in a hard bone, capable of motion in the ſnail, by the power of its muſcles.

The optic nerves of the firſt pair of horns having ſpiral originations *kk*, ariſe on both ſides from the brain, which has been ſo contrived by the omnipotent wiſdom of God, that they might conveniently obey, and evolve or turn themſelves out, when the horn is, in ſo ſtupendous a manner, protruded forth out of the body; and to prevent the leaſt diſorder from this egreſs and regreſs, the omniſcient creator of the univerſe hath involved and fortified theſe nerves with ductile membranes *ll* and ligaments, with ſo much art, that no ſuch diſorder is ever to be feared. Nay, leſt this nerve ſhould be in any danger, when it is turned up and down inwardly in the cavity of the moveable horn, the wiſeſt of all architects has conſtructed that part of the muſcle which is fixed to the extremity of the horn in ſuch a manner, that at the ſame time it performs the office of a ſheath or caſe, wherein *m* the nerve lies in perfect ſafety, ſo that it appears to be faintly viſible through it; it may, however, be diſengaged from this covering, and then its ſpiral windings appear ſo admirably conſtructed *n*, that any perſon who contemplates this prodigy of nature, muſt be aſtoniſhed and ſtruck with amazement.

That muſcular, and at the ſame time membranous, little part which covers the nerves, is ſo tender in this place, that it may be very eaſily ſeparated, and divided into parts, with the point of a needle, or with an ivory bodkin; after which the muſcle reſembles as it were a grey delicate membrane, Tab. IV. fig. VI. *o*. The nerve itſelf ſwells by degrees into a globular form *p*, at the end of which is placed an eye *q*; of which I ſhall preſently ſpeak particularly.

The little nerves *r* of the two lower horns, do not ariſe directly from the brain, but have ſome parts intervening; but as to the twiſted nerves *s*, which are conveyed towards the fore part of the skin, to the root or baſis of the horns, they have there the ſame texture with that of the nerves that belong to the upper horns, though they have no eyes in the ends of them. The ſame order, in every reſpect, the ſame wiſdom and providence, are manifeſted in the conſtruction of theſe lower, as we have before mentioned in relation to the upper, pair of horns.

The two ſmaller of theſe little nerves ſpring immediately from the baſis of the brain, and are diſpatched in the ſame manner as to the larger horns *t*. In fine, all the muſcular parts of the palate, mouth, and jaws, which I ſhall hereafter deſcribe particularly, are furniſhed with two ſmall nerves *v*, which adminiſter to their motion; theſe I have repreſented in Tab. VI. fig. I. at the letters *bb*, where may be ſeen the method in which they are bent, when the brain is moved forward.

Fig. VII. *a*. The eye itſelf is very conſpicuous, and in ſome degree of the form of a round onion; but is a little flatt or ſmooth on the verge, and ſwells ſomewhat into a point where the ſight is exerted. But I could not obſerve that the eye has more than one coat, which covers it on the inſide, and which I call the uvea; if this uvea be in the leaſt, ever ſo lightly, touched, it makes the place it lies on very black, like ink: this I ſhall ſhew more clearly hereafter, for I now only deſcribe the eye, as it appeared to me through a microſcope. I here likewiſe ſhew the grey muſcular membrane *bbb*, which covers the eye; and I alſo exhibit the manner, wherein the circumference of the eye is connected with it: the optic nerve *c* is here repreſented likewiſe larger than natural, and its texture and form are ſhewn; and after what manner the eyes are placed thereon. Here is likewiſe ſhewn how the inverted horn *d* is connected to all theſe parts, and the cavity *e* it paſſes through; as alſo after what manner, and in what place, it is protuberant *f*, on account of the muſcle which draws it back into the body of the creature; and which is there fixed in the end of it.

I have obſerved five diſtinct and viſible parts in the eye of the Snail, as clear as the ſun at noon; firſt, the external coat, which I call the uvea; afterwards on the inſide, the aqueous, the chryſtalline, and the vitreous, humours, with the arachnoide tunic. But who can credit this? for it ſeems indeed improbable that on a point not bigger than the nib of a writing pen, ſuch exquiſite art, and ſo many miracles, ſhould be diſplayed. But what is there that equals the power of God, who is the contriver and creator of all theſe things? nor can there be any room for chance here, unleſs in the opinion of thoſe, who deſtroy and reject the ſteps of natural knowledge, leſt they ſhould aſcend in her paths, and be led to the wiſeſt of architects; and, by contemplating even the moſt minute of his works, be incited to proſtrate themſelves with a ſacred reverence, and moſt profound humility before him, bidding adieu to their own opinions and former life, which, without the love of God, has been hitherto addicted only to the world.

If the uvea be viewed with a microſcope, it has the appearance of a turnip roaſted in the fire, until it is very black, and burſt in ſome places; and has ſome viſible ſmall fibres, which connect it with the adjacent parts. But when this eye and its coat are put, with a very fine pencil, into the fourth part of a drop of water, for more water would overflow it, and, after ſtirring them a little, they are cautiouſly and ſlowly touched; the water at length becomes black likewiſe, and ſhews the remains of the particles ſwimming in it: the ſame thing will happen alſo if an experiment be made on the uvea of the human eye. But when all the moiſture is wiped off clean, and a little wound is made in the eye with two fine and very ſharp needles, Tab. IV. fig. VIII. *a*, the aqueous *b* humour will be obſerved to burſt out from thence. If this eye be afterwards preſs'd more roughly, you will ſee a more clammy humour iſſuing from thence *c*; which is properly the vitreous humour. And laſtly, after that, the chryſtalline humour, which is of a harder conſiſtence, and of a plane round figure *d*; it is limpid, tranſparent and ſhining; but it does not run out, until you break the arachnoide coat, which covers it, and which is the fifth part of this eye. From theſe obſervations we learn clearly, how "the "inviſible things of God, from the creation of "the world, are clearly ſeen, being underſtood "from the things that are made, even his eter-"nal power and godhead, ſo that they are "without excuſe, becauſe that when they "knew God, they glorified him not as God." "Rom. i. 20, 21.

The

The uſe of the eye in the Snail, and the manner wherein it exerciſes its viſual faculty, is a matter of great difficulty to inveſtigate. The grey coat, Tab. IV. fig. VII. *bbb*, which is the expanſion of the muſcle of the eye, and may be very much dilated and contracted, ſeems to me to move various ways; nay, that it ſerves as a cover like our eye-lids: but the bigneſs or ſmallneſs of the pupil or foramen, or aperture of the uvea, and in what manner it is contracted or dilated, as light and objects vary, I have not hitherto been able to obſerve, nay, I never yet ſaw the pupil of the eye in a Snail; nor ſhould any wonder at this, if in the human eye, though ſo big, the foramen or aperture of the pupil is no larger than a Pidgeon's quill; what a ſmall and fine aperture then muſt the pupil have in this little point, and how few rays can paſs into it? however, I don't doubt but the pupil is contractable and dilatable; for I have obſerved the ciliary duct there, by which, when the pupil is dilated, the eyes of the Snail can receive the humors, and collect external viſible objects, which, after paſſing the humors, are afterwards received in the retina, placed underneath at the bottom of the uvea, by the optic nerve; which is the cauſe of viſion. Hence it may, perhaps, be juſtly inferred, that the ſight of the Snail muſt of neceſſity be very dim; for we ourſelves do not ſee clearly in the day-time, if we go into a houſe out of the open air; the pupil of our eye is by that contracted in ſuch a manner, that fewer rays of light are collected in our eye. Nay, perhaps the Snail does not receive the rays of light and objects but at a diſtance, and only ſees them through a cloud as it were, and cannot diſtinctly know them near at hand; as the man born blind is ſaid in the goſpel to have ſeen men like walking trees: I could not at leaſt hitherto obſerve, that the Snail ſees well the things which are near it, notwithſtanding all the attempts I made for this purpoſe. In the eye of the Mole I have likewiſe ſeen, even without a microſcope, the three humors beforementioned, but they are there larger, and eaſier to be diſtinguiſhed, though it is probable even this creature cannot ſee diſtinctly under the earth.

I ſhall conclude this chapter with admiring the ſtrange and remarkable things which I have ſhewn in it, from the cleareſt experiments, and which ſeem to me the more admirable, the more diligently I meditate upon them: God truly every where ſhews that he is worthy of the moſt humble adoration in all his works, which we may and ought diligently to ſearch into, but can never fully comprehend.

CHAP. II.

Of the lips, mouth, teeth, tongue, palate, œſophagus or gullet, and certain muſcles of the Snail.

BETWEEN the two lower horns of this creature are ſeen its lips on the outſide, Tab. IV. fig. I. *c*, and whilſt the Snail draws them aſunder, the intermediate skin is obſerved to be ſet like the edge of a ſaw, as it were with prominent little teeth. This can never be ſeen better than while the Snail is eating, or when the mouth, palate, and jaws, together with the outward skin, are taken off and diſſected. In this caſe, Tab. V. fig. I. the teeth *b* immediately appear behind that skin *a*; and in a boiled Snail they are rendered very viſible, Tab. IV. fig. IV. *r*, becauſe the skin and lips become thus contracted. Theſe teeth are connected by a certain horny concretion, Tab. V. fig. II. *a*, the teeth themſelves being all made of a horny ſubſtance; and they are of a light red colour. Since therefore all theſe teeth are connected one with the other, they ought to be eſteemed, in ſome meaſure, as one tooth. They are eight *b* in number, and ſome are larger and more prominent than others, as appears by the microſcope. This little part is made in the form of a circle *c*, its convex ſide lying on the inſide upwards, towards the ſkin, to which it is ſtrongly connected; but its toothed concave ſide, with which it bites, is directed on the outſide. In the middle of the convex ſurface of this tooth, there is a ſmall furrow, in which ſome of the muſcles that move the whole are fixed. The tooth afterwards becoming inſenſibly membranaceous, expands itſelf like a pretty large-pyramid or bodkin, fig. I. *c*, and in that form conſtitutes a great part of the palate, which, on each ſide of this expanſion, is beautifully variegated with ſmall ruddy points: theſe here and there ſhew little parts that are ſomewhat hard, and of a horny ſubſtance, and ſerve to prevent the inward part of the body from being wounded or hurt, in caſe the Snail ſhould at any time ſwallow any thing too hard or rough. But this cannot be ſeen, unleſs the inward parts of the mouth be firſt diſſected, and taken out ſeparately. Then two ſmall, narrow holes or apertures *d* are ſeen on the upper and under part in the palate, which convey the ſaliva out of its ducts into the mouth.

In the lower part of the mouth, or where our lower jaw is placed, are, in the Snail on the fore part, two ſmall fleſhy ſubſtances *e*, which may be called the inward lips, for they contribute greatly to direct the paſſage of the food; that is, to carry it towards the gullet, and thruſt it down. Behind theſe, a certain very delicate and tender membranous crooked cartilage preſent fents itfelf to view; at the loweft and inward part of which the tongue, Tab. V. fig. III. *a*, and its mufcles take root. The tongue itfelf lies under the concave fold or winding of this cartilage, fig. I. *f*, and is covered therewith when the Snail fwallows its food, juft as the epiglottis in us covers the top of the afpera arteria or wind-pipe, when we are eating, left any thing fhould flip into the wind-pipe. This texture of the tongue in the Snail approaches yet nearer to that of the tongue of the Serpent kind, which in the fame manner fhuts itfelf up in fuch a cavity. The tongue of the Snail is thus placed in a remarkable cavity, and its bafis or root lies in the cavity of the neck towards the belly, where it is obferved to fwell like a fpheroid or oblong globe, fig. III. *b*; but a little on the infide of that part where the tongue appears, there is feen a very delicate mufcle, which draws the tongue together with the whole mouth, palate, jaws, and even the brain itfelf, inwardly into the belly, or at leaft into the neck. See Tab. IV. fig. VI. and Tab. VI. fig. II, *e*, *f*, *g*.

On the tip of the tongue of the Snail *c*, there is a little horny bone, cut, as it were, into two or three very tender little teeth; with which, as with a hook, the Snail, when it is about to eat, firft lays hold of the fmall herb, and immediately after fuddenly fnatches and pulls the piece into its mouth; afterwards it nips them pretty faft with its teeth, fo that the noife it makes in biting and eating may be fometimes heard very diftinctly. The Snail will fometimes fwallow a piece as big as an hemp-feed. Thefe parts of the mouth have three mufcles remarkably delicate, by the affiftance of which they are, at the creature's pleafure, moved out of the cavity of the body. Thefe mufcles are fixed in the lower fide of thefe parts *d*, which are reprefented invertedly in this figure. As thefe creatures are moft immoderate devourers of vegetables, the keepers of vine-yards in the wine countries anxioufly gather them, when the vine puts forth its tender buds and firft leaves, and tread them under foot. This I have feen tranfacted as a work of great confequence in France. We may therefore reckon Snails as a part of the hoft of God, wherewith he can chaftife bad people in the fame manner as he did the Ægyptians, with voracious infects of the fame nature.

C H A P. III.

Of the tafte, fmell, and certain actions of the Snail.

I For a confiderable time kept in my chamber, and provided with neceffary food, feveral Snails: thefe were inclofed in a box, placed in a wooden bowl, and covered with a mat full of holes, through which they could ftretch their necks, that I might be able to find out their manner of acting, and fometimes view them with a microfcope. I fed them with radifhes, lettuces, forrel, mallows, and other fucculent and dried vegetables, which, after keeping them a little in water, I gave them frefh every evening; for they naturally eat in the morning and evening, and they love juicy and frefh herbs much better than old and withered ones. From this I obferved, that they had a nice appetite and tafte, as well as other creatures, for which purpofe they have alfo guftatory nerves.

They have likewife a very quick fmell: this I obferved, when I moved a little frefh food towards them, for they immediately perceived it by the fcent, and crept out of their little fhells and came to it. Thus they were kept alive; but as they were in a dry place in my chamber, I at length obferved they did not thrive there for want of dew and rain; nay, that fometimes they loft their appetite, fince they would lie contracted within their fhells, and were hidden entirely in their horny fkin. But I at length found out a method of giving them rain, as it were; which I did, that they might come into the light again, and feek fuch food as I laid before them. From this I obferved how little we are able to do by our own boafted powers; who, from our very miferable infirmities, cannot, I will not fay, make, or even accurately examine, but fcarce can with our beft diligence give thefe animals due food or nourifhment.

In order to give them water in the manner before mentioned, I made ufe of a brafs tube, to which was annexed, by a worm, a fmall globe of the fame fubftance, which was pierced with fine fmall holes, and had been originally made for the purpofe of watering fome plants, for feeding other infects. This machine forms a very beautiful kind of rain, that falls in little drops. As foon as the Snails feel this little rain, they immediately begin to creep: in the mean time, it is pleafant to fee with what velocity they can turn in their little horns, and hide them in the infide of their body, as foon as the little drops fall upon them; fo exquifite a fenfe have they in thefe tender parts, and indeed the whole body. This creature is very timorous, and retires into its fhell, when it finds itfelf difturbed by the leaft thing that it is not ufed to. If it be ftruck or handled, it not only retires very haftily into its fhell, but it immediately covers its whole body with a glutinous moifture.

Whether Snails have the fenfe of hearing, I could not difcover by experiment; indeed, I have not obferved any fign of it in them, though

though I have made a very loud and harſh noiſe about them. I find, however, that many creatures, to whom authors have denied this faculty, enjoy it perfectly; for example, the Camelion. I have likewiſe obſerved that Frogs and Fiſhes have this ſenſe; nay, Fiſh have a wonderful labyrinth of the ear for that purpoſe.

CHAP. IV.

Of the ſtructure and uſe of the verge or lip of the Snail, and of its reſpiration and voice, with other experiments: alſo of its glands, veſſels, and what it has in the place of feet.

HAVING deſcribed the eyes, mouth, and teeth, and treated of the ſmell and taſte of the Snail; it is proper I ſhould now treat of the aperture, through which the parts of generation occaſionally diſcloſe themſelves. This I ſhall conſider, when I come to ſpeak of thoſe parts themſelves, but previouſly to that, I ſhall ſay ſomething of its lip, or the fleſhy verge at the head, and of the apertures in it, as alſo of the fringed margin of the body, and the little excreſcences viſible on thoſe parts, and of the veſſels that run between them.

Tab. IV. fig. I. The verge that ſurrounds the whole body of the Snail is not ſo broad within as on the outſide, and is connected very cloſely to the extremity of the ſhell both inwardly and outwardly. As this is provided with a great number of muſcles, it accordingly acts with various motions, ſuitable to the different intentions of the Snail. Hence it is, that its true figure cannot be determined, for it is continually contracting, expanding, and changing its form. Where it is annexed to the upper part of the Snail's body, it exhibits two ſingular inciſions like two little tongues; and underneath the right ſide of the belly, it has a remarkable aperture, Tab. IV. fig. I. *g*, which ſerves to take in air; beſides which, it has another *f*, whereby the fæces or excrements are voided, as if by a ſmall, oblong and curled inteſtine. The colour of this verge is white, with certain yellow ſpots, grounded, as it were, on a pale tranſparent green. On the inſide, where it is joined to the ſhell, it is of a blackiſh colour, ſomewhat approaching to blue. It has different uſes, as appears both from what has been hitherto ſaid, and from what I ſhall hereafter obſerve, when I come to treat at large of the Snail's bone.

On the inſide, this verge is arched, as it were, and reaches with its cavities upwards, towards the pointed extremity of the body, to the windings of which, theſe cavities are adopted. Above, in the inward ſurface of the border, there are ſeveral veins, Tab. V. fig. IV. *a*, which run there naked or uncovered. But below in its cavity, almoſt underneath, on the left ſide, and in the declivity of the body, is placed the heart *c*, which may be ſeen to beat, even through the external ſkin, before that part is taken off: I have therefore marked its figure from the origin with points, Tab. V. fig. IV. *l*. This heart and its veins are continually refreſhed with the air, which the Snail impels into it through the aperture of its verge, Tab. V. fig. IV. *b*: for as the Snail rolls its body out of the ſhell, ſo in proportion it drives the air into the cavity of its verge; and again, according as it draws back its body into the ſhell, ſo it likewiſe expels the air from thence. This may be eſteemed ſomething analogous to reſpiration, as I have ſhewn in the year 1667, in my treatiſe on that ſubject, and exemplified particularly in the caſe of the garden Snail.

When the Snail has crept out of its ſhell, and is put into water, the air contained in the cavity of this verge makes it ſwim on the ſurface; but when the Snail is within its ſtony ſkin, and the cavity of its verge is cloſed and compreſſed, it ſinks to the bottom, if it be thrown into the water. But if the Snail, as it lies in the water, creeps again out of its ſhell, the cavity of the verge is immediately filled with the water ruſhing into it, which then does the buſineſs of air, which would have been impelled thither; hence it happens, that by a new kind of reſpiration, this water is ſometimes moved within and ſometimes without the ſhell, according as the Snail rolls its body out, or draws it into it.

The Snail has no voice, nor makes any noiſe, except that it produces a kind of hiſſing when touched with a ſtick, or any thing elſe, and ſuddenly draws in its body; for then, as the aperture through which the air is conveyed, is in a manner ſtopt up, it cannot readily get out; and this cauſes the hiſſing ſound.

Sometimes it happens that, do what we will, we cannot get the Snail out of its ſhell, in order to make this experiment, by which we might ſee that the air is forced into and out of the body, through the aperture of the verge. But if you have a mind to make the experiment, and obſerve in what a wonderful manner this aperture then ſhuts and opens itſelf, you muſt ſtrike the ſhell a little on the hinder part with the back of a knife; then immediately the Snail, compelled to it by the pain that it feels, will creep forward, and will plainly ſhew the opening through which the air paſſes, together with the manner of its reſpiration.

The extreme fringed margins of the body are planted as it were with numerous glandular tubercles or excreſcences, Tab. IV. fig. I. *bbb*, from

from which the mucus or ſlimy moiſture iſſues. Theſe tubercles are covered with a great number of veſſels, which run between and furniſh them with matter for the ſlimy humour. Theſe glands project beyond the ſurface of the skin, and are covered as it were with white tranſparent points, between which, as between ridges, or in furrows, the veſſels are ſeen to creep. This order is contrary to that which the all-wiſe Creator of the world hath choſen in the leaves of trees; for in the latter, the veins and nerves are uſually ſomewhat prominent, and the ſucculent part is depreſſed and placed between them.

The greateſt part of the ſubſtance of theſe fringed margins conſiſts of three membranes. The firſt and uppermoſt of theſe is a glandular skin; the middle one is a glandular, but thin, membrane; and the loweſt is a ſomewhat thicker membrane ſmooth and ſlippery. Under theſe the body of the Snail is interwoven with ſtrong muſcles, by the help of which, and with a ſingular kind of motion, reſembling, as it were, the waves and billows of the ſea, it moves at pleaſure its ſhell and whole body. Theſe fringes therefore perform the office of feet in this little animal, and they may be properly called the general foot of the body. This whole part is tender and ſpungy; yet, when it is pricked with a needle, it can contract its muſcles with ſo much force, that it draws up and joins itſelf together, ſo as to become as hard as leather.

The part of the body which lies under theſe is very white, and is covered with an even skin, which ſeems to me more tender than the former; but it is glandular like that, and is fitter for motion, by reaſon of its fineneſs. If the Snail be ſuffered to creep, this motion may be obſerved very beautifully; for if the glaſs be inverted, as the Snail is creeping on it, this admirable motion will be perfectly conſpicuous: it reſembles ſmall waves, which, when agitated with a gentle wind, ſlowly follow each other; nor can I explain this motion by a more proper example.

As to the motion of the animal ſpirits being obſerved, like ſmall globules moving from the head to the tail, and again from the tail to the head, in a naked Snail thrown into the water; it is indeed a mere chimerical notion, invented by thoſe philoſophers who make no experiments to guide them, but grow pale over their books only. The reaſon of the appearance which gave birth to the opinion, is this, that when the Snail is thrown into the water, ſome air always remains fixed in the mucus of the body, which never ſhews any regular or determinate motion, although it really has a very ſtrong one; for the little bubbles always retain their order and ſituation among themſelves, though they are contracted and expanded with the body; that is, they are heaped one upon another, and again ſeparated from each other from time to time.

CHAP. V.

Of the actions, and of the ſtrength and life of the Snail. How it is to be killed for diſſection, with further experiments; and an account of the effect ſalt has on this creature.

WHEN Snails are diſpoſed to reſt, ſo as to remain quiet without any motion of their verge or foot, they diſcharge a great quantity of ſlimy matter from their bodies, which, when dried, anſwers the purpoſe of a couch or hammock, in which they reſt. This they do in the day-time, and they will lie in this manner as long as it rains, or the atmoſphere continues cool; for nothing diſtreſſes them more than drought.

From this we learn alſo, that their ſlimy humour, which, at other times is clear and white, is more coloured, or has greater variety of tincts, the leſs of it they have in their veſſels and glands.

Theſe creatures are very fond of company at the time they are increaſing their ſhell, for then hundreds of them gather together in ſhady places, that they may be at leiſure for that buſineſs, lying quiet and cloſe to each other, eſpecially for ſome days before they begin to copulate; as I ſhall ſhew in its proper place.

Life is very ſtrong in them, inſomuch that they will live ſix or ſeven days under water. Nay, if they are wounded, and even dragged from their skin or ſhell, they will ſtill live four days, provided they are put into water. They are ſo ſtrong, that they can very eaſily creep forward, and move themſelves to all quarters, with another Snail ſticking to their ſhell; nay, one will ſometimes draw two others. The period of their natural lives cannot be certainly determined, but I am inclined to think they live to a very great age, which may be probably conjectured from the ſlow increaſe of their ſhell: on the ſurface of their ſhells are ſeen a very great number of the ſame kind of marks, Tab. IV. fig. 11. *s*, obſervable in a cow's horn, from which the country people compute the age of that creature.

The diſſecting Snails has coſt me great labour; for this operation is very difficult, and muſt be performed whilſt they are living. If we ſprinkle the Snail with ſalt, it is not conſumed, as is generally thought, but only killed, and then the ſtrong contraction of the muſcles draws up all the internal parts to ſuch a degree, that nothing can be ſeen diſtinctly. All the

the ſlimy humour is then diſcharged out of the body; ſo that I obſerved, that the ſpermatic parts themſelves were rendered three times ſmaller in this ſpecies of Snails, which is indeed very worthy of obſervation. Salt therefore ſeems to me to be a matter proper for cleanſing the Snail, for by this means all its humours are diſcharged. The inſect might otherwiſe be rubbed over with ſome purgative medicines, in order to try what effect they would produce; and, indeed, the ſucceſs of ſuch an experiment would be of ſome uſe in the medicinal art. I have often reſolved but have not had opportunities to try it. I think that the act of purging in our inteſtines is performed in the ſame manner, that this effect is produced on the outſide of the Snail; for the acrid, pungent, and provocative ſtimulus, irritates all the glandular parts of our inteſtines; and theſe parts are ſituated on the skin of the Snail, whereby they throw off and diſcharge the humours contained in them; and at the ſame time waſh away, as it were, every thing they find offenſive. This is manifeſt in the ſaliva, which is copiouſly diſcharged from our ſalival ducts, when any acrid and ſtimulating remedies are held in the mouth. This any perſon may experience very clearly, if he chews the roots of pellitory of Spain.

I cannot therefore agree that purging is peculiar only to a few particular medicines, which the practice has ſelected for that purpoſe; or that particular humours are expelled from the body, by ſuch as are commonly called ſpecific purgatives; as if theſe knew, from reaſon and judgment, how to diſtinguiſh water from phlegm, and the latter from all other ſuperfluous humours; and to ſecrete this only, and throw it out of the body. Whereas, it is more agreeable to experience, that, that matter only is diſcharged, wherewith the body abounds moſt, and which is more than any other copious in its veſſels at that time. If this be ſo, it will be ſufficient to obſerve, in regard to purgatives, whether they be hot, dry, cold, or moiſt; nor will there be any further neceſſity to load the memory with new-invented names and fictitious diſtinctions.

It is improper to put Snails into ſpirit of wine, oil of turpentine, or any other ſuch liquors, in order to kill them; and though I have ſometimes killed other inſects with the vapour of lighted ſulphur, that they might remain whole for the diſſection; yet I have fancied the fitteſt and beſt contrivance for this purpoſe, is to kill the Snail ſlowly, or by degrees, by keeping it under the water. This method is attended with this great advantage, that the Snail never contracts its muſcular parts; which, on the contrary, are beautifully expanded: for the water penetrating into the orifice, of its glands, mixes with the ſlimy humour there, and, at the ſame time, by dilating, ſurpriſingly expands the whole body. Hence I have found that many parts, which otherwiſe are hidden, or cannot be inveſtigated, but by great labour, become viſible with great familiarity, as the aperture of the genital organs with the penis and uterus, the teeth alſo, and the form of the verge or extremity of the body, the glands and other parts are all rendered conſpicuous on account of the water contained in them; the Snails are, therefore, by this means, rendered fit for diſſection.

Some curious perſons feed this kind of Snail in their gardens, and at their country ſeats, as I remember to have ſeen at the Hague and Culenburgh, in the kitchen gardens of the illuſtrious counts Maurice and Waldeck; and in many other places, particular in grotto's, which are adorned with ſea productions. The propereſt time for removing theſe Snails is in the winter, for then they lie cloſe in their ſhells without motion, and are defended therein by a particular kind of operculum, or cover, formed by a hardened quantity of the ſlimy moiſture vented for that purpoſe, which very exactly cloſes up the entrance into the ſhell. If they are to be ſent from place to place in ſummer, the beſt way is to ſend them wrapped up in a quantity of freſh herbage; when they are deſigned to be eat, they ſhould be put into a bag, and chopped ſtraw ſcattered between them, by the pricking of which they are prevented from creeping out of their ſhells.

CHAP. VI.

Of the internal parts of Snails; and firſt of the heart, its auricle, the vena cava, and aorta. And alſo of the blood, and its perpetual circulation. Of the difference of the ſlimy humour from the blood. Of the cavities of the verge, and alſo of the ſacculus calcarius, or bag of alkaline matter. To which is added, a curious experiment, pertaining to the motion of the muſcles.

AS I have hitherto been taking a ſurvey of many of the external, and of ſome of the internal, parts of the Snail, I propoſe to go on now to a deſcription of its ſhell: but then it will be moſt proper to diſcourſe of that, after I ſhall have deſcribed thoſe parts, from whence the ſhell itſelf derives its nutriment and growth. As I have already gone through the examination of the principal internal parts, I ſhall not confine myſelf rigidly here to the order uſually obſerved by anatomiſts, who commence their inquiries with the belly or head; they do this to get rid of thoſe parts, which would firſt taint; but no noxious ſubject is to be feared in this caſe, and the animal itſelf being ſmall, I have choſen rather to treat firſt thoroughly of thofe parts, which were firft obvious to me. Neither need I be uneafy, if I have delineated one part fomewhat larger, and the other fomewhat lefs; the microfcope not admitting of greater accuracy: and indeed this avails nothing in our attempts to inculcate a knowledge of the fubject, unlefs fome particular points may be more diftinctly underftood, if on that occafion, the parts are exhibited a little larger than the life.

The beft manner of diffecting the Snail is, the fhell Tab. IV. fig. II. *i*, being pulled off, to begin at the verge of the body, fig. I. *e*; which alfo fhould be cut off from the left fide, with a fine pair of fciffors; in the doing this, taking care not to pierce the apertures *g*, fituated on its right *f*, thefe ftill remaining unhurt, the verge is to be feparated from the body, which vifibly adheres to it below; for otherwife, unlefs thefe apertures be carefully avoided, the outlet of the inteftines, and the paffage of the alkaline bag, will be equally injured.

In this management, what firft meets the eye, is the skin of the fubjacent body, which is concealed by the upper and under part of the verge, or a membranaceous fubftance, as with a covering, being much more delicate about that place, and of a whitifh or palifh colour, and compofed of oblong mufcular fibres. If you have nicely feparated this part of the internal skin, you will fee the tranfverfe mufcles lying under it; which, though not altogether colourlefs, are in fome degree tranfparent; and on both fides, in the foft or bending part of the belly, there will be obferved certain mufcles refembling a faw, which ftretch their tendons above the peritonæum; but the fmall mufcle, running tranfverly, is fituated above the peritonæum, under which it lies. All thefe mufcles ferve to prefs the body inwards, and to move forwards the contents of the inteftines, and of the fpermatic veffels.

But if after this the verge, together with its membranaceous parts, be drawn backwards over the bending of the body, and then cut off from the place where it adheres, then immediately appear the veins, Tab. V. fig. IV. *a*, which run beneath toward the verge *b*, and the heart *c*, with its auricle *d*, and the vena cava juft dawning out of it; together with the various cavities, in which the air is moved, and fome other fmall parts befide, fuch as the alkaline bag *e*, and its duct lying next to the inteftine, the inteftinum rectum *f* itfelf, the liver, and certain parts belonging to the fpermatic veffels. Some of thefe I fhall now defcribe in their order, and of the others afterwards in their place. Firft, of the heart.

The heart is fituate in the middle of the Snail's body, near the extremity of the arch of the verge, which furrounds the whole body; and at that place, a little to the left, in the bending of the body, by reafon of the thinnefs of the inteftine membranes, which are perfectly tranfparent, Tab. IV. fig. I. *l*, it is difcerned moving. It is included in an extremely thin bag or pericardium, in whofe cavity there is ample abundance of watery moifture, as clear as the pureft chryftal. The pericardium being diffected, immediately appears the beating heart, Tab. V. fig. IV. *c*, with its auricle *d*; which, being of a membranaceous and exceeding delicate texture, is feen to be interwove within, with divers as well flefhy as membranaceous fibres, in the fame manner as is feen in the auricles of the heart of a man, and other animals. The heart itfelf is of a flefhy fubftance, and of a pale reddifh colour, exhibiting a mufcle, which for the fpace of a day will continue wafting away into water, and yet not be cleared from all its blood. The external fuperficies of the heart is fmooth, and it is fhaped like a pear; but the internal parts are uneven, with feveral flefhy columns, hairs, and fibres, much the fame as we obferve in the hearts of men and brutes: hence it is that the heart may be eafily diftinguifhed by the many finufes and angles in it, and it is very fibrous. At its entrance, near the auricle, there adhere two little femi-lunar valves *c*, which ferve to hinder the blood from returning into the auricle. But as there is only one auricle to the heart, fo is it only found in one cavity; and agreeably to this, there are alfo found two kinds of veffels there, namely, the veins and arteries. The veins, above the auricle *d* of the heart, are confpicuous without much pains, and in particular the vena cava may be obvioufly feen; out of which others, juft fpringing forth, are interwoven amongft one another after a furprifing manner, and form an elegant kind of net-work. The arteries are not difcovered without greater difficulty, nor can they ever be feen, but at the firft opening of the body. The beginning of the aorta, or great artery, is about that place without the belly, where the heart is united to the calcarious bag *e*; and the great artery derives its origin from the cone, or more acute extremity of the heart, and is a little dilated, at its very beginning, as is common in fifhes; immediately from this part it difperfes its ramifications every way, both through the internal parts of the body, and outwardly among the membranes, equally backward to the fpire, and forward; firft, indeed, refpecting thofe parts it borders upon, namely, the calcarious bag *e*, the inteftines, the liver, the ftomach, and the fpermatick veffels; then immediately proceeding to the coat invefting the liver, and then to the mufcles, nerves, and little glands of the skin. I have delineated *h* fome of the more remarkable ramifications, only with their divifions, and have marked the reft of its body, and its fpiral fhape, with points *iiii*, that the fituation of thefe parts might thence be underftood.

The blood contained in the heart, and its arteries, appears of a whitifh colour, inclining fomething to blue; and hence it differs very much from that of men and brutes; for the blood of all thofe is of a deep red; but, as the blood in fmall animals, excepting thofe only which live in the bowels of the earth, as many as I have known of them, want that purple colour; for this reafon then authors, who are only wife in their own fpeculation, have called them animalcula exfanguia, or animalcules without blood, though even in fome human bodies, there has been obferved fometimes white blood in the arteries. The blood of the Snail is of a glutinous confiftence, clammy, and pituitous or phlegmatic; if poured into water, it fhews itfelf like a sky-coloured cloud, which gradually expands, and grows more and more tenuous, and at length quite vanifhes; and is indeed a very pleafant fight.

The blood which remains from the nutrition of the membranes, returns through many extremely fmall veins toward the heart, there to undergo a new concoction. Thefe veins are chiefly fcattered about the external parts of the body, and are there very confpicuous; for thofe veffels which we fee there, are almoft all confpicuous, as they may be feen among the pointed little glands of the verge. All thefe veins converge in one large trunk called the vena cava; which, as we have juft faid, may very plainly be feen on the internal fuperficies of that arched membranaceous part of the rim or fringe of the Snail, Tab. V. fig. IV. *b*; for the veins run off, under and through this verge or fringe, and afterwards difcharge their contents into the auricle *d* of the heart; which then, by its contraction and fyftole, again protrudes this blood into the heart *c*; and the heart, with a manifeft circulation, again ejects it into the arteries, and thofe again into the veins; that the motion may never be interrupted, but the blood maintain its courfe through the body. Hence the pulfation of the heart is firft difcerned in its auricle; but afterwards in the heart itfelf; thofe veins which fpring from the vena cava, are formed and difperfed with fuch wonderful artifice, in the aforementioned membrane, that I have determined to fet forth an accurate drawing of them; to the end, that the works of God may be fo much the more clearly underftood, and more firmly impreffed on the memory.

The heart, with its auricle, is never more diftinctly feen, than when it is cut open through the vena cava, diftended with a blaft, and then half dried; but if it be dried too much, it is lefs forcibly contracted; and its internal fabric and fmall valves cannot be fo conveniently viewed. But feeing thefe veffels all contain a whitifh or lightly-coloured blood, from which they may be eafily taken for nerves; it is therefore expedient that they be firft filled with an injection of fome coloured matter; which operation, by reafon of the exceeding fmallnefs and finenefs of thofe parts, is indeed a very curious and difficult task.

For thofe who delight to engage in fuch a procefs, there are colours of that fort which fubfide; and thofe ought to be mixed with fo fine a liquor, that it may pafs through the pores of the veffels, and fly off into the air. But if any one ufe a liquor of a fimple colour, then they will be all of one tinge, nor can any thing be diftinctly exhibited to the eye. I might explain many of the operations and artifices requifite to the perfecting this matter; but this part of the work, beyond my expectation and defign, has grown redundant enough under my hands already.

The difference between the blood and the flimy humour in the Snail is very remarkable, and may be obvioufly known only by the colour and confiftence; for though the blood is thin and fluid in the veins, it becomes tenacious after it is taken out of thofe veffels. Nay, although it be immediately thrown into water, it does not mix therewith, unlefs it be fhook a little. On the other hand, the flimy humour fecreted by the glands, takes a long time before it is diffolved in water, becaufe it is tenacious and thick; and this is of a white colour, and may, therefore, by thofe qualities, be eafily diftinguifhed from the blood; whenever the wounded Snail is thrown into the water, in order to mix the blood and this flimy humour with it.

The blood, being laid upon white paper, leaves no glofs; whereas the flimy humour covers it, as it were, with a bright varnifh, like filver; it may therefore be mixed with colours, to give them a glofs. Thofe, who eat Snails, efteem their blood very highly, and call it their liquor, taking particular care that it fhould not be loft; and I think they, as well as thofe who eat oyfters, have fome reafon for fo doing.

After what manner the flimy humour diftils from the glands of the fkin, may be feen in this manner; the fkin muft be wiped with fpungy blotting paper, until none of the flimy humour is feen, or till the whole is cleared off; then the fkin muft be taken between the fingers and preffed gently; and if this be done under the microfcope, the flimy humour will be feen to come out infenfibly, from the glandular pores of the fkin, like clear and minute points; thefe, by continuing the preffure, will become fmall drops; and thefe, in fome time gathering together, will form a confiderable collection of this matter; fo that the whole fkin will be moiftened, and become glutinous.

The cavity of the arched verge, in which the air moves, forms a round bow or arch, occafioned by the membrane's expanding itfelf againft the fhell; but this happens only when the Snail lies in its fhell; for when it is taken from thence, the membrane of the verge immediately flips into the parts underneath; fince it is no longer fuftained by this fupport againft the fhell, being connected to the latter only by the toughnefs of the mucus,

or

or ſlimy humour. If this membrane be again ſwelled up from its aperture for air, it will be obſerved to expand itſelf very beautifully againſt the ſhell. This cavity in the right ſide of the body reaches to the turn of the inteſtines; but in the left ſide, where the heart is ſituated, it goes according to the windings of the liver, and follows the turnings of the latter, unto the third and ſecond convolutions of the inteſtines in the body.

In this arch of the Snail's verge, near to the heart and its auricle, there is ſeen, Tab. V. fig. IV. *e*, a certain oblong, triangular little part, to which the heart *c* is fixed and united, there being nothing between them but the pericardium. But on the outſide it ſwells, Tab. IV. fig. I. *n*, through the ſkin; and is very viſible in a boiled Snail, when taken out of its ſhell, fig. IV. *o*. This latter likewiſe ſhews the figure of the body at that time, that is, the convolutions *p* of the liver, and after what manner the verge contracts itſelf *q*. The colour of this little part is like that of grey aſhes mixed with water. On the hinder part it is connected, Tab. V. fig. V. *l*, very ſtrongly with a certain part of the inteſtines and liver; but that part of it which is ſeen through the outmoſt membrane which covers the body, is obſerved to be interwoven with many veſſels. On the other ſide, its colour is more wateriſh *m* than where it is of an aſhy-grey, and connected to the pericardium *k*.

I firſt thought that little part was the ſpleen, but when I viewed it more accurately, I obſerved that it diſcharged itſelf into a pretty large duct, which runs near the inteſtinum rectum, or ſtraight gut, fig. IV. *f*, and in my opinion opens into it. I therefore now believe this part to be a glandular little body, or a ſacculus or bag, whereby the calcarious matter of the blood is drained from the body, and depoſited in the inteſtinum rectum, or ſtraight gut; and accordingly we find that ſuch a matter is there ſometimes mixed with the excrements. If this little part be diſſected, and put into water, it exhibits a glandular ſubſtance; but as it abounds with a grey calcarious humour, it makes the water muddy. On the ſide oppoſite to the inteſtine it appears ſomewhat bright, and ſeems to conſiſt of a glaſſy ſubſtance; it has the ſame aſpect in ſeveral places; alſo in the middle, where it ſeems divided into little grains, which are viſible underneath: it taſtes like aſhes.

C H A P. VII.

Of the liver, bile, ſtomach, inteſtines, and ſalival veſſels of the Snail.

THE liver, which for the moſt part lies in the hinder portion of the ſhell, forms a ſpiral convolution there with the inteſtines, Tab. V. fig. VI. *a*; as may be ſeen on the outſide, Tab IV. fig. I. *k*. It is further divided into divers lobes, Tab. V. fig. VI. *bbb*, according to the different courſe of the inteſtines, which make as many diviſions in it, as they have turnings and windings. Beſides theſe, the liver is very full of greater and ſmaller veſſels, which are diſperſed through every part of it, fig. IX. *a*. It has likewiſe its particular thoracic or chyliferous ducts, fig. VIII. *a*, which diſcharge themſelves into the inteſtines, without any intermediate gall-bladder; in the ſame manner as in Horſes, Pigeons, and other animals, which are ſaid, though without any foundation, to have no bile. I could perceive no remarkable bitterneſs in the bile of the Snail.

The liver itſelf ſeems to conſiſt of ſmall equi-diſtant little grains, called glands by the great anatomiſt Malpighius; to whoſe judgment we ought to give great credit, ſince one can ſcarce find his equal in anatomical knowledge. The liver is of a dark brown colour, a little approaching to green: the hardneſs and ſubſtance of it, are like thoſe of the ſpleen in a man. It abounds with a juice or humour of a yellowiſh green colour. In the upper part, where the liver turns round, its outward coat, which is covered with little whitiſh points, grows greener. It has very few lobes on the inſide. Nothing is more ſavoury in a boiled Snail than the liver, which, I think, is alſo very eaſy of degeſtion: whereas, on the contrary, all its muſcles are hard and tough, except the ſpermatic veſſels, which are likewiſe very pleaſant eating.

The Snail's ſtomach, fig. VI. *c*, is placed in the cavity of the neck and belly, and conſiſts, as in man, of three coats, notwithſtanding its being very tender and thin: it is alſo provided with veins and arteries. It is of a white tranſparent colour like parchment; but when diſtended with food or air, it has the colour of the moſt tranſparent membrane: when empty, it appears full of oblong grooves, Tab. V. fig. IV. *n*, which exhibit an agreable ſight; for they are ſo many contracted muſcles, which corrugate the coat in this manner. The ſtomach grows narrow by degrees, fig. VI. *d*, and forms by that contraction its lower orifice, called the Pylorus. After this follows the ſmall gut *bbb*, between which the liver is principally ſituated. After theſe inteſtines have turned themſelves two or three times, then they form the inteſtinum rectum, or ſtraight gut *e*, which opens, with its foramen, into the Snail's verge *f*. About the ſpiral convolution of the body is obſerved *g* a place, where the bile diſcharges itſelf into the beginning of the inteſtines; which appears more evidently, if thoſe biliary ducts are ſomewhat ſeparated, fig.

fig. VIII. *a*; ſo that the whole region of the ſtomach *b*, ſmall *c* and great guts *d*, be parted from the liver. If the inteſtines and the liver be inverted, ſome of the parts before-mentioned may be ſeen more diſtinctly; that is, the liver itſelf, fig. VII. *a*, and the ſmall guts in their natural ſituation *b*; then the inteſtinum rectum, or ſtraight gut *c*, and the ſtomach *d*.

And here we muſt obſerve, that two very beautiful veſſels run, fig. IV. *oo*, along the ſtomach and the gullet, or œſophagus, which diſcharge themſelves into the upper part of the palate of the mouth, fig. I. *d*. Theſe veſſels are of the ſame ſtructure with that part of the epididymis in man, which lies upon the teſticles, and they are of the colour of an agate. On the inſide they are hollow and contain a clear liquor, which they diſcharge by two ſmall apertures which open into the mouth. They are, therefore, plainly the ſalival ducts of the Snail, ſuch as are likewiſe obſerved in man and brutes, and are ſituated either near the ſame place, or a little lower.

Theſe two little veſſels ariſe from two ſmall, clear, and ſnowy parts, fig. IV. *pp*, joined together in the middle, and divided into various little lobes: you would eaſily believe that they were nothing more than fat. A beautiful little veſſel *q* runs through the whole ſurface, which brings them nouriſhment and moiſture, and, ariſing out of a very high place under the verge, where the body begins to bend, comes to this part, and gives a great many branches to each of theſe ſmall parts. Theſe little parts are likewiſe, by the help of different veſſels, which ſeem to be ſo many ſmall and tender filaments, laterally connected with the ſtomach. The ſalival ducts themſelves are, by certain ſingular veſſels or ligaments, alſo connected with the ſtomach. I firſt indeed thought that this ſmall part was the pancreas, but experience has taught me the contrary, and likewiſe that it is not fat; for it cannot be melted by fire, nor is it inflammable, if put on a bit of glaſs and applied to a lighted candle.

C H A P. VIII.

Of the genitals, penis, uterus, teſticles, ovary, and other parts ſubſervient to generation.

THE ſpermatic veſſels are placed not only in the fore part of the neck, belly, and back of the Snail, but being twiſted like vine tendrils, follow the convolutions or windings of the body itſelf, and extend themſelves to the extreme end of the liver; ſo that they may be juſtly reckoned amongſt the moſt remarkable parts of the body. Before they can be ſeen, the ſkin muſt be diſſected, and ſome of the membranes and muſcles removed; and among the latter there is a very elegant muſcle, which, with many fibres, reaches obliquely from one ſide of the body to the other, and ſhews itſelf beautifully upon the ſtomach, and thoſe parts that ſerve for generation.

The male and female organs of generation are both in the ſame Snail, and the penis and uterus, being naturally united, grow firmly together; ſo that many of the parts are common to both. The ſmall parts, from the ſtructure of which it is known that they belong to the male organs, are the penis, Tab. V. fig. x. *a*, with its ſharp, twiſted, oblong appendage, which, at the extreme end, is round, in the form of a pear *bb*. To the female parts belong the uterus *ccc* and its ovary *dd*, which opens into the cavity of the uterus; that the little eggs may be increaſed and covered with moiſture therein, as may be ſeen very beautifully in the Ray-Fiſh; nay, and in ſome degree, in the uterus of Hens. But in other animals, as in Tortoiſes, Lizards, and Camelions, there is found a greater agreement in this reſpect, with the Snail, than I could obſerve in fowls.

As to the parts which have a mutual communication among themſelves, to theſe may be referred the teſticles: theſe are, as it were, a congeries or heap of oblong filaments *e*. Then the hidden appendages of the uterus *f*, and a certain common duct between the penis and the uterus, Tab. V. fig. x. *g*. Afterwards there is an oblong vas deferens, which opens at the end by a ſmall tube into the uterus *i*, and has a little ball in the form of a pear at its extremity *k*. Laſtly, there is a very beautiful curled veſſel *l*, of the ſame ſtructure with the epididymis in man and quadrupedes, which being twiſted in, like a little chain, diſcharges itſelf by a ſmall tube *m*, into the beginning of the uterus and end of the ovary.

Having enumerated theſe things in general, I ſhall now treat of each part in particular, and aſſign the reaſon why I have called ſome of them common to both organs, and others proper to one or the other. As to the penis *a*, it is nervous and of a muſcular texture, conſiſting, as it were, of three parts; the firſt is a muſcular membrane, then the inward conſtruction, wherein, as in a prepuce, the penis may move up and down; and laſtly, the internal porous membranes, which truſs up the penis on the inſide. Hence it is, that if the penis be cut off in the act of coition, no more than the outward membrane which covered it, and out of which it ſtretched itſelf, remains in the body. It is all white, and is firm, and, as it moves up and down very eaſily on the inſide, ſo it as eaſily moves through the aperture

ture of the genitals out of the body, and can enlarge and ftiffen itfelf for that end. For this purpofe it has not only a mufcular texture, but it is likewife provided with a peculiar mufcle *o*, by the ftrength of which it is thruft out.

The act of coition is performed in this manner; firft, the outward aperture of the genitals opens itfelf in the right fide of the neck, fig. XVII. *a*; which, when it has more and more infenfibly dilated and expanded its orifice, then the two inward orifices, as well of the penis as uterus, fig. XVIII. *b*, creep out of the body. Then the penis erecting itfelf, fig. XIX. *c*, and pufhing foftly out of one of thefe orifices, comes in fight; but the other aperture, that of the uterus, lies open *d*, to receive the penis of the other Snail at the time of coition. So that the penis *e* of the one Snail is put into the aperture of the neck of the uterus *f* of the other; and again, the penis of the latter *h* is likewife received by the aperture of the uterus *g* of the former. Each of thefe Snails being therefore excited by a reciprocal ftimulating impetus to venery, each impregnates and conceives, fertilizes and is fertilized, and ejects and receives the femen.

After coition all thefe parts are drawn into the body; for which purpofe the penis has a fomewhat long and even mufcle, Tab. V. fig. x. *p*, which is inferted under the tranfverfal or oblique mufcle of the abdomen, where the verge of the Snail's body is: and that this part fhould not want fenfe, it has likewife a nerve *q*.

The parts of the uterus have alfo their nerves and mufcles, fome of which may be feen in the neck, near the root of the four horns. The matrix itfelf is a tender, oblong, white and curled *ccc* little tube, which appears moft remarkable when it is diftended, fig. XVI. *r*, with air or wind; for then it turns itfelf into very admirable convolutions, being jointed to a ligament, fig. x. *nnn*, which connects all its folds, and is of a ftronger ftructure than the membranous and hollow parts of the tube of the uterus. This feems defigned for fome particular ufe; for it appears full of glands, fo that I firft took it for the ovary itfelf: for indeed all the veins of the uterus, of which there are many, are faftened in this ligament, and pafs through it towards the uterus. But, in other refpects, neither the uterus nor ovary, fig. x. *dd*, have any thing remarkable in them, as long as the former has no eggs in it. The ovary is not vifible, unlefs it appears like an oblong, white, tender, foft and triangular little part, and contains a fubftance like the melt of Perch. So fmall and invifible are the little eggs of the Snail before coition!

Again, the uterus is faftened near the verge of the Snail, and is there connected with the upper part of the abdomen. There are likewife fome mufcles which ferve to contract the uterus, a larger one *s*, and a fmaller *t*, which is inferted behind the long mufcle *p* of the penis. The uterus has alfo its nerve *v* there, as will appear more clearly in the defcription of the brain; where it will likewife be fhewn that thefe mufcles alfo give fome affiftance to move the brain on the inner part.

That the penis and uterus in the Snail have many parts in common between them, I am inclined to affert, for this reafon; becaufe thefe parts are forced to move their contents through common paffages, as is feen in the fperm from the tefticles, and on other occafions. Thefe tefticles *e*, as we have before obferved, confift of a clufter or heap of oblong filaments; and the fame holds in almoft all fpecies of this genus of infects: it is even fo univerfal, that it takes place in man and quadrupeds; for their tefticles are formed of fuch filaments. There are fixty-fix of thefe threads in the Snail: they are of a whitifh colour, and, in their inward ftructure, refemble hollow tubes, each being clofed up at its extremity. They arife from two trunks, and are divided in a wonderful manner, as it were, into twigs, Tab. V. fig. XI. *x*. The femen is of a fnowy colour, and of the fame thicknefs and clamminefs as in the males of Bees. I know nothing that bears a greater refemblance to this part, than the pancreas of fifh; a defcription of which I have inferted in a work of Commelinus, which I publifhed; and I have delineated the figures with my own hands.

The hidden appendage, fig. x. *f*, of the uterus is a very beautiful, white, nervous and mufcular part, of a firmer fubftance and texture. If it be diffected, it muft be done very cautioufly and with an even hand: it is then difcovered, that at the root or bafis in the hinder part, it has, fig. XII. *y*, a globular and round little part in the form of a pear; from which arifes a fharp, hard and crooked ftyle, not unlike a fharp awl. This little bone being taken out and viewed with a microfcope, refembles a tranfparent, glittering, very fmall, fcale of a fifh deprived of its fkin. At the root, fig. XIII. *a*, on the hinder part, where this little bone is connected to the globular little part, it exhibits fome incifions or fiffures covered with coats, which penetrate inwardly from the external parts into its cavity. I have counted fourteen of thefe incifions: it appears, in general, equal and round *b*, and ends fomewhat fharp like a needle: then it forms, in its circumference, four margents or prominent borders *c*, between which are feen fome remarkable ridges and furrows. This appears very plain when this minute part is diffected, fig. XIV. *e*; for then it is manifeft that it is hollow on the infide; fo that a hair put into it, almoft entirely paffes through it. Within the cavity of this little bone, there is contained a limpid or clear humour; but where its root is connected with the globular part, fig. XIII. *b*, it is all hollow and very tender, fo that it is eafily broke in that part, if it be handled in the leaft roughly or carelefsly. It ferments ftrongly ſtrongly with aqua fortis: hence I call it an alcaline little bone.

I could not find out the uſe of this little part. I thought indeed at firſt that it was the penis, but experience convinced me of the contrary. It is however certain, that it is of ſome uſe in generation; for after coition, ſuch little parts are commonly found where the Snails have been together. I have obſerved alſo the ſame thing in other kinds of Snails, till at length I made uſe of it as a ſign to diſcover whether the buſineſs of generation had been over. In ſome Snails which were not given to venery, I found this little part ſo ſmall, that it was hardly one fourth ſo big as that already deſcribed: it was like a point, ſlender, ſhort, and tender. In ſome it was larger, in others ſmaller, that is, as far as I could judge, the nearer they approached to the time of generation, or the further they were from it. It is ſometimes partly yellow, but for the moſt part it is tranſparent and very white; it ſeems, however, to be ſubject to accretion, like corals, as I ſhall demonſtrate more clearly in the Snail-ſtone. I remember to have ſometimes ſeen in a Cuttle-fiſh, an entire little bag full of ſuch white ſmall parts, which lay there free and diſengaged among a glutinous humor, but they conſiſted of a very ſoft ſubſtance, and were much larger. This fiſh has gills likewiſe, and other ſuch wonderful parts; ſo that this animal deſerves very particular conſideration, though much could not be hitherto known or ſaid concerning it.

The common little tube that lies between the penis and uterus, Tab. V. fig. x. *g*, is not very remarkable; I only obſerved that it was hollow. But that other, vas deferens *hh*, ſeems to ſupply more ample matter for ſpeculation, both becauſe it opens into the uterus *i*, and that it has a little ball or globe *k* in the form of a pear, which contains a fluid of a pale purple colour, ſomewhat glutinous, and not thin. This little ball lies next to the heart in the body; ſo that the great artery is carried round that pipe with which the ball is connected; but what uſe this little part is of, I could never hitherto diſcover. I once obſerved, that the little bone before-mentioned, penetrated into this veſſel, almoſt as far as its aperture into the uterus; but, to the beſt of my remembrance, I had then irritated the Snail at the time of coition, ſo that it drew in theſe parts of generation; for which reaſon I afterwards uſed to diſtinguiſh, in a particular manner, thoſe Snails which had exerciſed coition. Of what uſe this little globe or ball is, I am ignorant; I ſhould, however, be inclined to believe, that this is the part wherein the Purple-fiſh carries that precious dye, wherewith the garments of monarchs, and other great perſons, were coloured purple in the times of the Romans. To this the ſacred writings allude, when they ſay, "that the rich man was cloathed in purple."

I am likewiſe at a loſs to know of what uſe the curled little veſſel *l* is. I obſerved, however, that it is diſtributed into various little branches *z*, which, like ſo many tubes, ariſe from the oblong, round, and acute little part, placed near the extremity of the ſpiral liver, and there joined to the liver itſelf. But if this little part be divided, and opened or unfolded, with the top of an ivory bodkin filed ſharp, and ſomewhat ſoftened by ſteeping it in water, by which means it does not offer ſo much violence to the parts as a needle, it appears like a little tree or ſhrub adorned with leaves, Tab. V. fig. xv. *a*; with this difference only, that its extreme parts are ſtudded, or emboſſed and ſwollen, hollow on the inſide, and full of moiſture, which is probably conveyed by degrees into that curled ſmall veſſel reſembling a chain; but then the matter contained in this little part is more white and compact, and better digeſted.

Laſtly, we muſt obſerve that moſt of the parts hitherto enumerated, are placed behind in the ſpire of the ſhell, and are there ſeen through it in ſeveral places.

C H A P. IX.

Of the manner in which Snails mutually perform the buſineſs of coition.

HAVING hitherto, in part, ſhewn the method whereby Snails generate, I ſhall now give you a full deſcription thereof; ſince it is a matter very worthy of notice that, an hermaphrodite little creature ſhould have need of a companion for the purpoſe of generation.

The Snails gather together for ſome days before their coition, and lye quiet near each other, eating very little in the mean time; but they ſettle their bodies in ſuch a poſture, that the neck and head are placed upright. Thus, whilſt the ſhell of each reſts upon the earth, with its double head, the Snails are raiſed upwards, and they ſupport themſelves erect, by the extreme ends of the fringes and verge of their bodies, in the ſame manner as it is ſaid Serpents engender, that is, in an erect ſituation, and twiſted about each other.

At that time the verge, or its aperture, is continually open to take in the air; but the opening of the genitals in the neck is ſometimes obſerved to be alternately open and contracted. This action is performed in the ſame manner as the agitation of the outer parts of the vulva in Dogs and Hens, when they deſire coition. The Snails being thus animated, ſoftly approach each other, and apply their bodies one

one to the other, as ſmoothly as the palms and fingers of both hands can be graſped together: and by this means, not only their bodies, but their necks and heads, are raiſed up and preſſed cloſe to each other. Then are ſeen the moſt wonderful motions of their heads and eight horns, which ſurpaſs all imagination; like Turtles, they are continually obſerved to kiſs each other, and to join lip to lip. The horns are affected with ſuch various motions, that one can ſcarce think, how they can poſſibly have ſo many and ſuch different muſcles. Another circumſtance that deſerves notice is, that when they touch each other in the leaſt with their horns, they immediately draw them in, or move them up or down again, or ſideways; and theſe motions are often repeated.

Theſe motions ſometimes continue for three days, during which time the Snails turn in and out, and join together their genitals, ſo that the penis and uterus, of each, are ſometimes ſeen to hang entirely out of the body. But ſince I cannot obſerve that Snails have organs proper for ſeeing and diſcovering things near and at hand, but only for remote objects; hence it is, that for want of this knowledge, I cannot obſerve their coition but by chance. For though they very often ſhoot their genitals, like an arrow out of a bow, yet the coition is ſcarce performed once in three times. This miſtake ſeems to happen the oftener, becauſe every Snail carries its penis in the right ſide of its neck: it muſt therefore happen before they have turned their reſpective heads croſs-wiſe towards each other, that they often attempt a coition unſucceſsfully. But they have leiſure enough to repeat this buſineſs, ſince they feel for a long time the incentives of their venery, though they have already gone through the buſineſs of coition ten or twelve times before. Nay, I have known ſome of them indulge their venereal deſires three weeks afterwards, and that they repeated them again in ſix weeks after that.

But when they aſſociate in coition, as they ſhould do, each of them ſtretches its penis, together with the orifice of the uterus, entirely out of the body, which is not done by erection only, as it is in quadrupedes, but principally by turning the inward parts out, as happens in the penis of Drakes. The firſt thing that opens in the Snail is the aperture, that lies in the neck between the upper and lower horns, Tab. V. fig. XVII. *a*; then the inward parts of generation are obſerved to come out like two apertures, fig. XVIII. *b*; ſo that by this means the lower horn is puſhed out of its place, Tab. V. fig. XVIII. *k*: afterwards theſe parts are very ſuddenly thrown out of the body; yet ſo as that the aperture of the uterus appears firſt, fig. XIX. *d*, and immediately after the penis, the thicker part of which turns out firſt, and afterwards the ſharp part *c*. After this begins the coition, and the two lower horns are then ſo far thruſt out of their places, that they touch and preſs each other *l*. Theſe parts are afterwards remarkably ſwelled by the humours that flow towards them, ſo that they reſemble the clammy white of the boiled egg of a Lapwing, which, being mixed as it were with a tranſparent whiteneſs, makes a very agreeable ſight, reſembling an agat. For the appendage of the penis, fig. X. *bb*, is obſerved to run ſo far, and by the clearneſs of thoſe parts, is ſo evidently ſeen, that its motion is alſo obvious to the eye.

After coition the parts before-mentioned may be ſtill perceived for a quarter of an hour hanging out of the body, that is until their ſwelling has fallen, and then it is ſurpriſing to ſee what wonderful motions the penis has. But if any one ſhould in the mean time handle theſe parts, the Snail endeavours to draw them in by force, but however much it ſtretches all its nerves, yet it cannot by any force bring them in, unleſs they firſt become flaccid. A certain lympid moiſture then diſtils from theſe parts, which ſoon coagulates, and becomes tenacious and firm in the air. The upper horns being always bent like a circle in the venereal act, are obſerved not to move much, unleſs that they are ſometimes drawn in, and again ſtretched out. After all is finiſhed, the little creature, having wantonly conſumed the ſtrength of life, becomes dull and heavy; and thence calmly retiring into its ſhell, reſts quietly without much creeping, until the furious luſt of generation gathers new ſtrength, and effaces the memory of the uneaſineſs ſuffered after the former coition.

In a Snail, diſſected a little time after the act of generation, I obſerved that the penis was ſmaller, but the uterus a little more expanded and glutinous in its cavity. The ovary was manifeſtly ſwelled, and was longer, thicker, and larger, ſo that it now ſeemed full of ſperm like milk. Afterwards, however, I ſaw it much larger, and filled with more glutinous moiſture. But in five weeks after coition, the ovary became yellow, and like real glue; yet the eggs were very ſoft like ſlime, and were ſcarce viſible. When I afterwards viewed the ovary in ſuch a boiled Snail, every thing was callous, and as far as I could diſcern, an infinite number of little eggs preſented themſelves in both the Snails, which had copulated with each other. The uterus itſelf was likewiſe at that time much more expanded, and became, as it were, glandulous; ſo that when thrown into the water, it ſwelled very much. When the eggs were held a little while in the hand, the fingers ſtuck together. Therefore the ovary, the longer it paſſed after the time of coition, became more tenacious, compact and yellow; for all the eggs of the Snails are covered with very clammy membranes, and are, at length, perfected in the uterus. They cannot remain in the ovary, ſince this is placed between the ſpiral part of the ſhell, and throws its eggs into the cavity of the uterus. Some Snails lay their eggs up and down on the ground, others tie them all together like a chain. I have ſeen a little chain of eggs of this kind, which the vulgar thought dropped down from heaven, and therefore immediately framed a great many ſuperſtitious fables concerning it: ſo far is ignorance the mother of error. The teſticles, after coition, are found deprived of their ſperm. The blind appendage of the uterus likewiſe, in the beginning, though not very much, became afterwards contracted, and had thrown off its bone. The common tube between the penis and uterus ſuffered no change. The vas deferens was more dilated, and in it, as I have ſaid, I found the little bone. Hence it is probable, that this little bone, at the time of coition, carries ſome of the ſpermatic humour through the upper tube of the vas deferens into the uterus; whilſt the penis, in the mean time, throws its ſperm from the inward part into it. To conclude, the little part in the form of a chain had undergone no change, unleſs that on the ſide near the ſpiral convolution of the liver, the veſſels that it diſtributed there, were here and there very unequally dilated and filled with a calcarious humour; except that ſome little round whitiſh membranes, which appear perforated in the middle, and marked with a black ſpot, were here and there obſerved fluctuating in its hollow canals, which reſemble the leaves of trees.

CHAP. X.

Of the brain and nerves, and in what manner thoſe parts have their muſcles, whereby they are moved backward and forward in the body; a wonderful particular not hitherto known in any animal.

IT is with very great difficulty that any certain and fixed place can be aſſigned to the brain of the Snail, as I have obſerved in the beginning of this account; ſince, like other parts, it has its muſcles, whereby it is ſometimes drawn forward, and ſometimes backward in the body. This motion of the brain is ſo wonderful in this little creature, that it deſerves the moſt ſerious conſideration. Since I have never hitherto, nor do I know, that any other has, obſerved any thing like it in any kind of animal; I ſhall, for that reaſon, minutely deſcribe the brain, and repreſent it by a figure, as I have ſeen it in a Snail, which I killed ſlowly under water. The brain is placed upon the ſtomach itſelf, which, together with its gullet, always paſſes through the aperture which the brain forms there. And this is not peculiar to Snails only, it holds likewiſe in Silkworms, and in all other inſects that I have hitherto examined. Hence it is, that when the ſtomach, with the gullet, and all parts of the mouth, are drawn up on the outſide, or down on the inſide; the brain being always placed upon the ſtomach, is transferred hither and thither with it. Since therefore all parts of the mouth may be, according to the diſſection of the brain before-mentioned, drawn forward and puſhed out; I ſhall, in the firſt place, expoſe to view all the parts of the jaws, mouth, and palate, Tab. VI. fig. 1. *a*. Leſt the ſtomach and its oeſophagus ſhould interfere in my giving a full and exact repreſentation of the brain and nerves, as they really are, I cut the ſtomach about the gullet *b*, by which means the brain is ſeen immediately. It conſiſts of two parts like little globes, and is therefore divided into two parts: from each of theſe globes ariſe a certain part of the ſpinal marrow, reſembling on each ſide a large nerve *dd*, both which parts are ſituated in ſuch a manner as to leave a gap or aperture for the paſſage of the ſtomach. Theſe parts, ſpringing from the brain, conſtitute the true principle or rudiments of the ſpinal marrow, and they meet again a little lower, and form a conſiderable knot, Tab. VI. fig. 1. *e*; from which, afterwards, ariſe all the reſt of the nerves that are diſtributed in the lower part of the body. There we are to obſerve, that the ſpinal marrow is double, not only in this creature, but alſo in man himſelf, and in quadrupedes; with this difference only, that in the latter it is preſently joined together by a certain intervening band, and immediately after incloſed in a common membrane. Nay, all the nerves in the latter, that ariſe from the marrow, form, each in its courſe, certain little knots or ſwellings, which are therefore at leaſt more numerous there. The ſame is ſeen in Silkworms, in which the two originations of the ſpinal marrow are many times tied.

This ſwelling of the ſpinal marrow in the Snail has its muſcles likewiſe, by the help of which it is moved up and down in the body. Its firſt muſcle is very ſmall *f*, ariſing from a coat which covers the ſwelling or production: from thence, paſſing under the ſtomach and brain, is at length inſerted by its tendon, in the lower region of the parts of the mouth, a little above the root of the tongue; therefore it can move this little knot and the brain towards the fore parts. The reſt of its muſcles, which draw it back again to the hinder parts, are common to the inward lips; for the muſcles of the latter run on each ſide over this ſwelling, and fix ſome of their tendons therein, though they are otherwiſe inſerted in the horny ſubſtance of the Snail. After theſe muſcles have paſſed over the ſwelling or production of the ſpinal marrow, they acquire a little nerve from that part which gives them the power of contraction. To avoid confuſion, I have here exhibited only a ſmall part *g* of theſe muſcles, with their little nerve, which is afterwards extended further

further from thence towards the ſpiral turnings of the Snail's body, being there probably of uſe to provide for ſeveral other parts.

We further obſerve two nerves *hh* ariſing from the brain, which are diſtributed into the ſeveral parts of the jaws, mouth and palate, and probably ſerve for divers uſes. But the optic nerves *ii* which have the eyes placed in their extremities, ſwelled out in form of little globes, are extremely beautiful. Behind theſe are diſcovered two other nerves *kk*, which reach, each with three ramifications, to the fore parts of the skin, and to the baſes or roots of the upper horns; and afterwards alſo give two little nerves *ll* to the lower horns, which are of the ſame ſtructure with the nerves of the upper, and are alike terminated with globular ends. Beyond theſe a pair of very tender nerves, Tab. VI. fig. I. *mm*, ſpring from the brain, each of which being divided into two branches, runs to the muſcles of the ſkin of the head, and is inſerted in each ſide of the Snail's lower horns. Laſtly, two larger nerves *nn*, are diſcovered, which run under the parts of the mouth, jaws and palate, and diſtribute themſelves over thoſe parts, and are deſigned probably for motion or taſting, or for both.

Again, ſome of the nerves which ſpring from the ſwelling or production of the ſpinal marrow, are inſerted in muſcles, ſituated in each ſide of the neck *oo*, to which they give motion. Others, on the contrary, are ſent away to the ſpermatic veſſels *p*, and to the coat and muſcles *q*, which cover and move them. Some nerves alſo iſſue *rr* from thoſe ſwellings, which are diſtributed in the muſcular parts that move the ſides of the body. Above, on the right ſide of this little knot, there ariſes an oblong little nerve, which is defended by a like muſcle, and reaches to the uterus *s*. This muſcle may probably alſo ſerve to move the ſpinal nerves on the inſide. Behind the former are two other oblong nerves, one of which bends back under the little nerve of the uterus; but the other, being again divided into two branches, is inſerted in the verge of the body *t*; at the upper part of which are ſtill ſeen ſome muſcular fibres, which iſſue from the tranſverſal muſcle of the abdomen, which is ſituated within, under the arch of the membrane of the verge. On the other, or left ſide, a like nerve is obſerved alſo *v*, which has the ſame inſertion, and ſerves for the ſame uſe, that is, to to give ſenſe and motion to thoſe parts. In the left ſide we are likewiſe to obſerve, what manifold and ſtrong nerves are tranſmitted to all the middle and lower parts of the body. We will firſt examine thoſe in the middle. Some nerves are there inſerted, Tab. VI. fig. I. *x*, between the tendons fig. II. *nn* of that ſtrong muſcle, which moves the middle of the body, and thoſe are ſent away to the ſeveral muſcles that run near it. A conſiderable number of little nerves beſides *yyy* are obſerved, ſome of which are long, others ſhorter, and ſome are divided into two, others into three lateral branches: theſe deſcend to the lower verge or foot of the body, in order to give it the power of feeling and moving. I have exhibited none of theſe nerves in the right ſide, to prevent confuſion *z*.

Here we ſhall conclude the preſent chapter. Now, reader, judge whether God has not ſhewn himſelf as magnificent and aſtoniſhing in the the texture of the brain and nerves of the Snail, as in the formation of the ſimilar parts of man; excepting only the mind and principle or ſeat of the underſtanding. As thoſe do not appear to the diſſecting knife, ſo they are leſs proper to come into our analogy or compariſon; for thoſe only obſerve and inveſtigate corporeal and ſpiritual things, and thence deſcend to the deepeſt abyſs of the wiſdom and ſecrets of God.

CHAP. XI.

Of the muſcles of the body and ſhell, which is the bones of the Snails: in what a wonderful manner this ſhell is formed on the inſide, and how it is increaſed and nouriſhed. Laſtly, how the Snail moves in its egg.

THOSE who have ſeen diſſections, or have any knowledge of anatomy, know, that the hiſtory of the muſcles cannot be accurately underſtood, before the bones in which they are inſerted are firſt known. For the latter are fixed points, towards which every thing in the body, that has a ſtrong motion, is drawn and moved. And though the naked Snails have properly no bones, yet they have a certain extremity, wherein muſcles are inſerted; as I ſhall ſhew in its proper place.

That wiſe architect, who alone framed and reduced all things into order, has likewiſe eſtabliſhed different rules in the compoſition of animals, by the aſſiſtance of which he has purſued the ſame ends and purpoſes, how greatly ſoever the ways and means to arrive at thoſe ends differ in various inſtances. In ſome animals the bones are found placed in the body, with fleſh ſpread about and affixed to them, as in a man, quadrupedes, and in ſome birds. In others, we can only find cartilages, wherein muſcles are inſerted, as in the Ray-fiſh and ſome others. The Cuttle-fiſh has only one bone in its body, except the noſe or ſnout. In ſome, which are ſo ſmall that they have no conſiderable bones, the muſcles are inſerted in the skin itſelf, or they meet together in certain callous or firm points, which are formed for that purpofe, and which, in particular places, are as hard as the fofter part of a Cow's horn. Though the methods hitherto mentioned, tending to one and the fame end, differ greatly among themfelves, the wife Creator of the univerfe has, befides, invented many others much more wonderful: in fome animals he has formed bones manifeftly on the furface, and put flefh between them with the moft exquifite art, as in the Cray-fifh, Crab, and many others; and he has likewife followed the fame rule in moft kinds of Infects, and likewife in this kind of Snails, to which the fhell is as a real bone. The immenfe power and wifdom of God fhew themfelves greateft and moft profound in thofe little animals, to which he has given both an horny fhell, and the harder coat of a Crab; fo that the mufcles of the fofter part are inferted in the fhelly fubftance of their bodies, whilft that very judicious architect has inferted the reft of them in a hard bone, which covers their body, and is continued therewith out of the fhell, as may be obferved in the Hermit-fifh. Though the Tortoife lives in a little houfe as it were, and carries its bones, like the fhell-fifh, on the outfide, yet God has again eftablifhed a different order in that creature, fince he has given it two forts of bones, fome which grow contiguous with the bone that covers it, and others which are fixed to it by the help of joints; fo that by this means the mufcles are in this creature ftrengthened with a double infertion. And as this exhibits a very uncommon object in a living Tortoife, fo the futures of the bones, which conftitute the outward fhell, are worthy of particular obfervation; for, in my opinion, they differ from the futures of the bones of all other creatures whatfoever, as I can demonftrate by a fhell that I keep in my collection. But fince this animal alfo lays eggs, that are covered with fhells, which I have feen in great numbers in the body; and fince thofe eggs muft be emitted through a very fmall aperture in the bone, on one fide of the tail, through which they can by no means naturally pafs, it is beyond all manner of doubt, that the futures of the bones in this creature, muft, at the time of the exclufion of the eggs, feparate from each other. Anatomifts, with all their force, oppofe the notion of fuch a thing happening in human fubjects at the time of delivery. I fhall not pronounce, for certain, how this matter is, but I believe moft firmly, that fuch a temporary feparation happens in Tortoifes.

To return to the bones and mufcles; we muft obferve, that the mufcles are not fimply inferted in the bone, but that a certain part of the bones themfelves conftitutes one of the extreme ends of the tendons of the mufcle, fo that the mufcles fixed in each fide in the bones have two bony extremities. Every mufcle therefore confifts of three parts; the middle part is flefh, but the two extremities are the white, membraneous, firm, and fibrous joints of this flefh, which become bony where they are inferted in the bone; or otherwife remain hard and compact, or become fofter and more tough, according to the different nature of the parts to which they are joined, and which they are conftituted to move. Hence it happens that a mufcle is fometimes inferted in a mufcle. Nay, which is furprifingly fingular and uncommon, Mr. Stenon has demonftrated to me, and to my very efteemed friend Dr. John Oort, in the eyes of birds, after what manner a mufcle paffes through a mufcle by its tendon, as through a pully, fo that the perforated mufcle can draw to itfelf, or let loofe the perforator, according as the tendon of the latter, paffing through the former, fhould be brought nearer or removed further; than which ftructure fcarce any thing appears more admirable.

After what manner the mufcles are inferted in the fhell or bone of the Snail, and united therewith, appears moft manifeftly when that houfe of the creature is opened, for it is then obferved, that all the principal tendons of the mufcles of its body, run, fome a little lower, others fomewhat higher and deeper, towards the fpiral part of the fhell, and are fixed, Tab. VI. fig. 11. *a*, in the fhell itfelf, or hard or ftony bone of the Snail. This may be feen particularly in that winding or finus of the fhell, which is the fecond from its lower aperture; I mean that through which the Snail throws out its body and verge or foot. There may, after this, be further obferved, the infertion of the two longeft mufcles *bb* of the Snail, which ferve principally to move that great and fmooth verge or border of the body, by the affiftance of which, as with a broad kind of foot, the Snail creeps forward, and moves from place to place; but this muft be done with a very flow pace, according to the proverb, "Slower than a Snail." Thofe mufcles in the middle of the body, where they are for the moft part inferted, form a ftrong tendon; between which, towards the hinder parts, is feen here and there fome moifture, which is yellowifh, pretty thick, and contained in peculiar little cells, of the ufe whereof I am hitherto entirely ignorant. Backward, under the extreme part of the fhell, we fee the fibres of thefe mufcles *c* run, which are inferted in thetail of the creature, or loweft extremity of the fringe, which is moved by them. Moreover, there is feen the parts, Tab. VI. fig. 11. *d*, wherein all the tendons of the mufcles of the verge, that furrounds the upper part of the Snail's body, have their origination. And thofe, together with the tendinous fkin that covers the whole fpiral part of the body, afterwards afcend to the laft or extreme point of the fhell, but are no where further inferted; they are only curled, and there they contract the extreme end of the liver, and move it occafionally, together with the inteftines. Above, and near the infertion of thefe, is feen a fmall mufcle *e*, which draws in the parts of the jaws and mouth, and the cartilage, with which the tongue is covered,

together

together with the palate, and fome other parts annexed. I defcribe and reprefent this in fuch a manner, that the bafis of the tongue *g*, and its fore-pointed extremity *f*, which is armed with a kind of horney teeth, may be clearly diftinguifhed; although they are all neceffarily put fomewhat out of their natural fituation. Afterwards appear thofe two admirable mufcles *hh*, which, by turning in the two upper horns through their cavity, draw the eyes back into the body; the curled foldings *ii* of the optic nerves are found to be tranfparent through thofe mufcles, and are feen to run towards the eyes. The eyes themfelves feem like two black points *kk*, over which a certain part of the horns thus drawn in ftill appears: under the former, are feen two plain, equal, or fmooth mufcles *ll*, which draw the lips and fome other parts of the mouth into the cavity of the body; at the fides of thefe appear a pair of mufcles *mm*, which are inferted in thofe of the lips before-mentioned, and ferve to draw back the two lower horns into the cavity of the Snail's neck. Between the mufcles hitherto defcribed, are found two very wonderful and ftrong mufcles *nn*, which are inferted with two firm and tough tendons in the middle of the body; this is varioufly and ftrongly moved by them, and is raifed or elevated into the orifice of the fhell by their power; between the tendons of thofe mufcles is the proper place of the fpinal marrow in the Snail, which from thence diftributes its nerves to all the adjacent parts; the latter fupplying the nervous fluid or moifture, and giving the power of moving and contracting; as may be feen very diftinctly in the body itfelf. But after what manner the bone of the little habitation or fhell of the Snail is formed, and what windings, partitions, cells, divifions, and cavities it has; this truly fingular piece of art may be traced very eafily in a natural fhell, as I have endeavoured to exprefs its ftructure, according to nature, with all the accuracy of which I was capable. Laftly, the extreme edge of the fringe or foot of the Snail, Tab. IV. fig. II. *qqqqq*, in which I have delineated all the mufcles hitherto mentioned, deferves to be carefully regarded. The flefh, and the fibres and tendons are of a fpotlefs white, fo that there is not much difference in this refpect between the flefhy and the tendinous part, unlefs for the fmallnefs and folidity of the fibres.

Thofe parts being, in the firft place, thus explained and underftood, I fhall proceed to defcribe and to expofe to fight the inward parts of the fhell. The firft part which deferves confideration, is the outward orifice of the fhell, fig. III. *a*; which being by little and little contracted and twined round, forms its fecond divifion *b*, and thence afterwards afcending further, it forms a third *c*, and at length a fourth *d*, and a fifthe, which is the laft, and has the extreme end of the liver placed in its cavity.

If any one diffects the fhell with a fine faw, made of a fmall piece of a watch fpring, and afterwards breaks open all the inward cells and divifions with a fharp pointed forceps, he will fee very beautifully how this turning about or winding on the infide is effected; and how the five feparate lodgements in the fhell are compofed and twifted in a fpiral form, as I have reprefented from the life, in Tab. VI. fig. IV. numbers 1, 2, 3, 4, and 5.

The fhell of the Snail makes as beautiful a figure, if it be prepared in the following manner; it is to be cut fo that the inward poft, or the columella or pillar, about which all the cells and inward divifions are turned, remains alone; in this cafe, in the upper end of the pillar, where the fifth and laft lodgement is opened, there is feen a fmall aperture, fig. V. *a*, which paffes *b* through the whole pillar, from top to bottom, and is always larger and wider at the entrance of the fhell, than where the decreafing windings are terminated. Thefe apertures are feen yet plainer, if the loweft part of the pillar be taken off, fig. VI. *c*, and the pillar itfelf confidered apart. In many kinds of thefe bony habitations, thefe apertures of the pillar are very plain, from this caufe, that all the windings of the fhell have each their particular and diftinct divifions, which are faftened and joined together in their twiftings: we are to except from this account, fuch fhells as have no winding, and are therefore called tubules or tubular fhells.

For thefe reafons, therefore, this kind of fhelly covering muft be conceived as a certain oblong, hollow, fharp, and flexible tube, which if rolled and turned round a fmall iron line or wire, and afterwards this thread or line were drawn away from it, would fhew fuch a perforated pillar, which would be the more exact, if all thofe foldings, together with their inclofures, were applied clofely to each other, and faftened and united together. And after this manner are almoft all kinds of fuch little fhelly habitations built, in whatever wonderful manner they appear to be turned or conftructed. This I myfelf have found, by ftrictly examining many different kinds of them which are in my father's mufæum. This appears however much clearer in fome fpecies than in others, in thofe fhells, particularly, which are called tubules, and which are twifted, Tab. VII. fig. V. *b*, only at their extremity. This conftruction is fo plain as to be beyond all manner of doubt. I fhall therefore hereafter exhibit other kinds of fhells in their proper places, that the difference may he known as far as poffible, and by the feweft examples.

From each of thefe larger habitations may be formed as many fmaller as can be defired, provided we firft break off the pillar and the internal ridges, and afterwards make them even and fmooth with a file. This is indeed contrary to the order of nature, for fhe always proceeds from the lefs, Tab. VI. fig. VII. *d*, to the

the greater *e*, and fo on to the greateft *f*. I have prepared by art in this manner the diftinct little fhells which I here exhibit as gradually augmented. And that the method whereby this increafe is performed by nature may be conceived, I fhall now defcribe and explain how this habitation of the Snail is increafed and augmented.

In this fpecies of Snails, I could never difcover the rudiment of the fhell in the egg itfelf; but by obferving other kinds I have found that the little egg laid by them produced always a very fmall but perfect Snail; and any perfon may know, from reafon, that it muft happen thus, fince the Snail's mufcles would not be otherwife ftrengthened by any infertion, which no body in his fenfes would even have thought; but I follow experience, as the only guide in this cafe. In other Snails I have often, through the outward fhell, feen the little Snail lying in the egg, and moving very diftinctly, before it came out, which I have been fo happy as to fhew to the illuftrious Van Beuningen, our ambaffador and conful. One remarkable thing is, that as foon as the Snail is come out of the egg, it is perceived to be fo large, that it feems wonderful how it could lie and move, fo preffed and wrapped up, in that elliptic and narrow cavity of the egg-fhell.

Again, fince the water Snails themfelves likewife move in the egg for fome days before they come out of it, hence one is inclined to conjecture, that the young Snail does not leave the fhell of its egg before it has arrived at a certain degree of growth; at which, having its little fhell fufficiently hardened, it is in a condition to creep out of the egg, and to increafe its flefh and bone, or hard covering, with the food it receives. This may likewife be feen in other animals, which bring with them into the world flefh and bones out of the uterus, and only perfect them infenfibly, by the ufe of their fucceeding food. By this means, the Snail's fhell is nourifhed, as well as its fofter parts; though the former is done in fuch a manner, as to lead one to think that it is differs in fome meafure from the latter.

It is befides this worthy of notice, that the fhell of the Snail has its particular periofteum, by which it is covered and inclofed. And the fame may be obferved outwardly about the horns of ftags, for thofe are likewife inclofed in a peculiar coat, which they rub off againft the trees, and in procefs of time wear away, that is, after the horns have acquired their full ftiffnefs, and the skin that furrounds them is no more nourifhed. I have found this membrane fo ftrong and tough in the fhells of fome Snails, that it would not yield to aqua fortis; but the fhell itfelf, rather than the periofteum, was corroded thereby. This membrane is likewife very confiderable in the fhells of fea Mufcles, for to this the Mufcles faften thofe filaments by which they hang together, and fix themfelves fo as to prevent their being carried away with the tide. The filament I fpeak of iffues from their body, and is very broad in the forepart, almoft like a piece of a leather, wherewith fome perfons draw on their fhoes; and by the affiftance of this, the Mufcles are not only joined to each other, but likewife cling firmly to rocks,wood, ftones, fea-weeds, or any thing that is near them. Thofe filaments in other kinds of Mufcles, as in the Pianna Marina, are called Byffus, and are that matter, of which, as of filk, that kind of very fine linnen ufed to be made, which, according to Rondeletius, was called Byffus, and in which the rich man mentioned in fcripture was clothed.

In the Snail whereof I here fpeak, the membrane before-mentioned is pretty ftrong, and it is vifible every where in all the notches of the fhell, and their interftices, Tab. IV. fig. II. *s*. In other fhells of the fame fpecies, I have fometimes found it worn out, by the creatures frequent creeping through ftony places; but it is always confpicuous near the aperture out of which the Snail creeps. If thofe who delight in natural curiofities, or have mufæums, find a fhell ftripped of this invefting membrane, they conclude that it was rolled in the fea long after the death of the creature originally contained in it.

I have fometimes obferved that the Snail, being about to inlarge its habitation, firft cleared away this periofteum with its little teeth, nay, that it bit off fome fmall pieces therefrom, and fwallowed them; however, I have obferved alfo, at other times, that the Snail cleaned the edge or margin of its fhell with its teeth, if it was covered with films, and that the Snail happened to reft for any confiderable time. I have likewife often found that the Snail, when it remains quiet for any time, forms films of that kind, and befprinkles them with a calcarious matter, and then thofe films will ferment with vinegar, as well as the fhell itfelf, when worn or rubbed in the duft. And indeed all thefe experiments evidently demonftrate that this habitation is the real skin, or rather the hard or ftony bone of the Snail, which covers it on the outfide.

But if this ftony fhell be accurately examined, it appears to confift of numerous fmall, tranfparent, and as it were membranaceous coats, which have infenfibly petrified, or affumed the nature of ftone; as may likewife be obferved in Craw-fifh immediately after they have caft their fhells, and in the bony fkulls of men, which are at firft only thin membranes, but are afterwards turned by degrees into bone. Thefe membranes are at firft like water, and afterwards grow folid and increafe, when many fibrous and angular particles grow by degrees under them, as may be feen moft evidently in the heads of abortive children. The fame things may be obferved in the Snail's fhell, if it be lightly calcined, and then put under the microfcope.

As

As to the method, whereby ſuch a ſhell is increaſed, the following are the chief particulars, the Snail's whole body is furniſhed with glands, from the orifices of which flows up a kind of mucus or thick matter, like ſmall and fine rays; which, like ſo many threads of ſilk or velvet, are joined together in one common cruſt or ſurface, and in proceſs of time are condenſed, and acquire the hardneſs which we obſerve in the ſhell. This mucus or thick humour then, is the firſt matter which grows into a membrane, and afterwards into a ſtony skin. Its filaments are very conſpicuous at the places where the windings of the ſhell are applied to each other.

The outward ſcale or enamel of the teeth, in men as well as in beaſts, likewiſe conſiſts of innumerable very ſmall and very fine filaments joined together, which I have found in ſome teeth hard and poliſhed, like real ſtone; though the teeth are at firſt but a kind of mucus or thick humour, and afterwards become membranous, and at length fully hard. I have ſeen the rudiments of teeth in abortions of five months old, which, together with their filaments, I now keep, and can ſhew in them this ſingular conſtruction.

My moſt reſpected friend, Mr. Stenon, has likewiſe diſcovered ſuch filaments in oyſter-ſhells, and made my father a preſent, for his muſeum, of a ſhell which was buried for a long ſeries of years under ground, in the mountains of Italy, and, by length of time and moiſture, inſenſibly had ſeparated, as it were, into many tender and ſmall ſhells: from this it is evident, that the ſhell itſelf was formed of thoſe, in its growth, in the manner I have explained. In corals I have found nearly the ſame method of accretion; that is, that they are firſt thin membranes, which, by an inſenſible increaſe of the little grains joined together, petrify; as may be ſeen in a work publiſhed by Mr. Boccone, of corals, in which are two letters of mine treating of the ſame matter.

If you likewiſe view the tendons of the Snail's muſcles, which are inſerted in this part of the ſhell, you will find that they have grown hard as a ſtone there; which is indeed eaſily known, both from the winding of the ſhell's pillar, which becomes larger by degrees, and from the inſertion of thoſe muſcles in the ſhell. In hens likewiſe, and in peacocks, the tendons of the muſcles are oſſified, or become by degrees hard as bones. Theſe tendons, eſpecially ſuch as are taken out of the lower parts of the foot, are made uſe of, by ſome with us, for toothpicks.

The opercula of the ſhells, Tab. IV. fig. III. *m*, have almoſt the ſame origin, though their ſubſtance approaches nearer to chalk or plaſter than to a ſtone; nor is it ſo hard, but is more ſpungy than the ſhell, and therefore is made thicker; but I have obſerved, that when the operculum or cover is finiſhed, and the creature enters deeper into the ſhell, it afterwards, under the membrane of the ſhell's operculum, produces, ſometimes two, ſometimes three membranes, of which ſome are thicker than others, and are more or leſs calcarious. About the center of this operculum, is likewiſe ſeen a membranous filament, which connects all thoſe membranes with the operculum, as if they were faſtened with a needle and thread. When the creature frames its operculum or cover, it retires by degrees more and more into the ſhell, ſo that the verge equally ſhuts up its whole cavity, and afterwards preſſes out the chalky moiſture, with the aſſiſtance probably of the ſacculus calcarius, or calcarious bag which we have deſcribed.

The principal part of the body that promotes the increaſe of the ſhell, is that verge of the Snail, which the creeping in of the Snail cauſes to ſwell ſo far beyond the extremity of its little habitation, as that creature wants to ſtretch and enlarge it, thus it preſſes by degrees a glutinous humour out of the glands of the body, and thereof immediately forms a membrane conſiſting of filaments, which it afterwards makes thicker and thicker, until it at length attains a due hardneſs and firmneſs, by the preſſure of the circumambient air. For this membrane is at firſt ſo weak and ſoft, that it breaks through on the ſlighteſt touch; and this is the reaſon why the halictations of Snails are found ſo often uneven with ſcars, and ſwellings on their ſurfaces.

If it ſhould happen that the ſhell be preſſed in by a fall, or by any other means, or be wounded or broken, theſe Snails know ſo well how to mend and conſolidate it by degrees, by the application of the petrifying humour, that it becomes more firm than it was before in the places which ſuffered the injury. The outward ſurface by this becomes very unequal and tuberous, but the inward ſmooth and poliſhed. Something like this is alſo obſerved in the fractured bones of animals, which nature can conſolidate again with a callous ſubſtance; but even thoſe are then alſo unequal on the ſurface after ſetting. We ſometimes meet with ribs of mutton in the ſame manner, which it is very certain have been formerly fractured. I have ſeen the ſame thing in different bones of men and other animals. I have ſometimes broke a Snail's ſhell ſo that I could put my little finger in the hole that I made, which, notwithſtanding, I have found filled up again in four days: ſo that the ſame means of accretion and tranſmutation, to all intents and purpoſes, are obſerved in the Snail's ſhell as in the bones of other animals, with this only difference, that the veſſels of the former are not conſpicuous; which may probably be owing to their ſmallneſs and delicacy, and becauſe the blood contained in them is white: but this makes no difference.

Another thing alſo very worthy of greater admiration is, that this ſhell will, even under water, whether it be freſh or ſalt, petrify or become hard as a ſtone, however much it has been like a fluid humour in the beginning. This may be feen in river and fea Snails. But what feems to me a greater paradox is, that fome infects frame their fhelly coverings, and weave their little nets under water, like Silk-worms, out of fmall and glutinous filaments; fo that thefe threads, which are fpun from a fine and fubtle humour, acquire their firmnefs, tenacity and hardnefs even in water, as well as the threads of Silk-worms do in the air. I can fhew fome very rare and uncommon experiments on this head in the water fhell-fifh which I preferve. Let me add, that I have feen a Snail die the third day after I had taken it out of its fhell; though in feparating it I had hurted none of the blood veffels, and had likewife carefully left untouched that part of the fhell wherein the mufcles were inferted; but that Snail before its death preffed out a certain membrane round the whole furface of its body. This membrane was the fame in all refpects as that on which I have made the preceeding experiments, and was intended by nature to fupply a new fhell. In the beginning the Snail was very fprightly; but afterwards it infenfibly languifhed more and more, and at length, contracting itfelf under its verge, it died. Here end my obfervations on this fpecies of Snails.

C H A P. XII.

Of the Hermit fifh, and Pinna Marina. Of the inward turnings or convolutions of the turbinated fhells. Of the Voluta or Cylinder, the Concha Veneris, and Pencil, and fome other fhells of the Snail kind.

IF all the things I have advanced in the preceding chapter be attentively weighed and confidered, it will appear clear as the light at noon, that the Snail's fhell is its real bone, without which it cannot live. Hence it appears what an idle fable that is which is eftablifhed even amongft thofe who ftudy fhell-fifhes, when they fhew fome of the Crab kind in their mufeums, adding at the fame time that they pafs from one fhell to another, devour the animals that lived in thofe fhells, and keep them for their own habitations. They dignify them with founding names and additions, as Soldiers, Hermits, and the like; and thus, having no experience, they commit grofs errors, and deceive themfelves as well as others with their idle imaginations.

Some years fince, when I was at the Hague, I employed fome fifhermen who lived at Scheveling, to bring me all the ftrange fifhes which they fhould catch. It fo happened that among the reft they brought many fmall Crabs, Tab. XI. fig. 1. *a*; each of which lived in a kind of twifted, round, fmooth and polifhed fhell; but when I viewed the animals themfelves more accurately, I obferved that they refembled Crabs only in their fore part, that is, they had four feet *gg*, and two forceps, of which the right *e* was much ftronger and thicker, than the left *f*. I further faw there two tender feelers or horns *dd*, and two prominent eyes *c*; and under the latter there were placed fome other fmall parts. The inward part or body of this Crab was fixed to the pillar of the fhell, by the tendons of its mufcles, but otherwife it was foft and confolidated, as in Wilks and other Marina or fea Snails.

Ariftotle and Ælian tell us, that in fome fhells there are both a Crab and Snail together; hence the Crab has got the name of Pinnophylax or fhell-keeper. Thefe anthors likewife harbour another ingenious opinion, which is, that the Crab provides food for its companion the Snail; fo that thefe two little animals live it feems, and have all neceffaries, in common, which is an admirable thing, and which has given fome authors occafion to frame feveral parables, and make various moral reflections. It is beyond doubt that this animal they defcribe was likewife a fpecies of the Cancellus or Hermit Crab, one part whereof, that which provides neceffaries, and creeps out of the fhell, is covered with a hard cruft; but that which remains within the fhell is the foft and tender part of the body; and as the fhell ferves in this part inftead of a skin or covering, there was therefore no need of a teftaceous cover or cruft, as we have already obferved with refpect to the Cancellus.

The Pinna is a fpecies of the Oftracodermon, and is at this time called Vinne in the Netherlands, by thofe who have a curiofity for things of this nature; becaufe, perhaps, the animal living within feeks its prey by violence, and catches and kills lefs creatures with its forceps. It may poffibly alfo have its name from hence, that its fhell is commonly as thin as the fin of a fifh, and when ftript of its skin, is tranfparent like the fcales of fifhes. This fhell is contracted into a fharp or pointed end on one part. In my father's mufeum are many fpecimens of thofe fhells, which are called by fome prickly Mufcles.

I fhall not deny that fmall Crabs are frequently found in the fhells of fea Snails, when their inhabitants have been killed and taken out of them; nay, and fometimes Star-fifh are found in the fame manner, for I faw this very thing in the town of Petten, on the fea coaft. But this happens only by chance, and thefe little animals cannot ftay long in thofe habitations; when hunger begins to incite, they go out for food. Thus, when I was looking for infects, I have, in company with

with Mr. Thevenot, and Mr. Stenon, found feveral fmall Crabs in the river Seine, in the bones of fome ox's skulls which had been thrown into that river.

The fhell in which the Hermit abovementioned lies, is on the infide twifted into the like windings as the operculated Wilk; I fhall therefore omit its figure in this place. But that the diverfity of the windings may be known, in fome meafure, in other fhells, I fhall now reprefent the inward windings of the turbinated kind. The common Turbo is of a very elegant ftructure; it begins at the bafis with broader windings, Tab. VII. fig. I. *a*, and, rifing by degrees obliquely, like a circular ftair-cafe, converges into an acute point *b*, and thus forms various cells and lodgments.

But the figure of the Voluta, or that called the Cylinder Snail, is much more beautiful, becaufe the convolution or winding is more complicate and intricate; its entrance, fig. II. *a*, growing narrower *b* by degrees, forms another round *c*, which afterwards, being ftill twifted or convoluted *d* round its pillar, produces beautiful and regularly fpiral tendrils, which grow narrower by degrees, and at length are loft. This ftructure truly merits admiration, for all things are there fo beautifully divided and feparated by inward divifions and cells, that they exhibit a labyrinth of miracles, into the inward cell of which we cannot obtain admittance, unlefs we firft pafs round all thefe windings. Nor can any one difcover its wonderful elegance, unlefs guided by the Ariadnean thread of an unwearied refearch into the works of God. The Almighty gives knowledge as the price of labour, which the heathens themfelves have declared.

No lefs admirable are the finufes of the Concha Veneris, with which the women in Holland adorn the ftrings tied to their keys, and polifh their whitened linen after bleaching. This fhell is conftructed with various convolutions, and unufual and amazing windings, like tendrils; and to all thofe convolutions of the inward part of the fhell, the body is fitted and made to agree by its bendings and windings. I have already explained in the Snail before defcribed how this is done. Its entrance, Tab. VII. fig. III. *a*, is beautifully fortified and divided into little teeth like thofe of a faw; fuch as are likewife obferved to be placed on the infide about each winding, as far as the extremity *b* of the fhell, which terminates in a very fharp and fmall point. But all thefe remarkable things cannot be exhibited in a fingle figure.

In the Penicilli Marini, which the French call pencils or plumes, the moft wife architect has difpofed their windings in a very different manner: they begin in the orifice, fig. IV. *a*, of the Penicillus, and infenfibly form another lodgment or apartment, with their notched or denticulated bendings; then as it were, diminifhing by degrees, and rifing again with broader convolutions, they form a third lodgment *c*; afterwards they decreafe more and more, and make a fourth *d*, fifth *e*, fixth *f*, and feventh *g* compartment. The laft is like a little ftring or tuft of filaments, and is properly the firft rudiment from which the Penicillus begins to increafe, and whence, by a gradual augmentation, it acquires or raifes all the reft of the compartments.

In the cabinets of the curious, there is kept a certain fpecies of Snails, which agrees in its internal conftruction, well enough with the Cornu Ammonis. This confifts of a fimple little tube, fig. VII. *a*, rolled into itfelf, very large before, narrower behind, and ending in a very fmall point. It differs from moft other fhells of Snails, becaufe it is divided on the infide into numerous compartments, by delicate partitions, which are tranfparent even on the outfide, 1, 2, 3, 4, 5, &c. In the fore end, the partition which is hollow like a faucer, is naked or plain to the eye, and has a fmall hole pierced through it there *a* *. If this hole be accurately viewed, it is found actually to open into the tubular appendage of the partition, which appendage or tube is inferted in the opening of the fecond partition, and the tube of the fecond into the aperture of the third, the third into the fourth, and fo afterwards to the end of the fhell.

All thefe things appear plainer, if the outward fhell of the Snail is picked off; for then the ftories or partitions, Tab. VII. fig. VIII. *bb*, fituate in the Snail's tube, are feen very plainly, as well as the little tube or fiphunculus, that reaches from the firft partition to the aperture and tube of the fecond, and the tube of the fecond to the third, and fo to the extremity of the Snail: all which may be feen about the inward fide of the curvature *c* of this creature very diftinctly. But fince thefe things cannot be fo diftinctly exhibited or underftood under its natural fize, I have thought it advifeable to reprefent, of thefe, feveral partitions confiderably magnified; in which figures, the acetabulum or partition appears firft in its compafs, fig. IX. *ddd*, and on the infide its inward fold, hollow like a fpoon. On the upper part of this is feen *e* a little aperture formed with the moft exquifite art. Behind this aperture is feen the tubular appendage of the acetabulum or partition, which, on the upper and lower fide of that partition, is ftretched out, like the crooked handle out of a certain fpoon, and is received very exactly into the aperture and tubular appendages of the partition, fig. X. *g*, and this again into the aperture and tube of the third *h*.

* All Nautali are of this ftructure, as alfo the Arthoceratilæ, as well as Cornua Ammonis, which are found petrified, being inhabitants of deep feas; whence they are never got up living, nor the fhell feen recent. In the large thick Nautilus, thefe partitions are forty or more in number, and there runs through them all a pipe; this is called the fiphunculus; the animal within is of the Sepia or Cuttle-fifh kind. In the Arthoceratilæ they are more numerous. We fee this fhell-foffil in the red ftones called Swedes paving, and ufed in court-yards, and for flat walks.

What

What has been hitherto ſaid, is far from completing the artificial ſtructure of this wonderful Snail: for as this Cornu Ammonis becomes ſmaller by degrees, ſo do its partitions, and their tubes *iiii* become leſs, until at length they become inviſible. I obſerve likewiſe, that theſe tubes of the partition are not connected together, but are only contiguous, and are put into each other, in the ſame manner as the tubes of teleſcopes, which receive each other in ſuch a manner as to be freely moveable. But on the contrary, the acetabula or partitions themſelves increaſe with the Snail's ſhell, and are united to it. I preſerve ſome of theſe acetabula, which ſhew their very elegant ſtructure, if their tubes are joined together; for which purpoſe, and that they ſhould not be eaſily loſt, I keep them together bound with a ſilver thread.

This Snail therefore agrees with all others in regard to its ſtructure, and its ſhell conſiſts of one crooked tube. It differs, however, from the reſt only in that the apartments or cells are placed in a different manner, and have perforated handles: theſe may be ſaid to form the pillar of this Snail, ſince they exactly receive each other.

I never ſaw this ſhell with its Snail but empty only in my father's cabinet. I ſhould therefore be very glad to know, by what means the body of this little creature, which inhabits that ſhelly houſe, is placed there, and whether it extends through all thoſe apertures from cell to cell, and is interſected, as it were, in ſo many places; or whether it lives only in the extreme apartment, and is inſerted with its muſcles in the tubes of the ſhell. But however much I wiſh to be gratified in this particular, I ſhall never, probably, accompliſh my deſire. It would therefore be proper for thoſe who viſit foreign countries, for the ſake of commerce, to import ſuch things; for though they have never ſo little curioſity or taſte for theſe ſtudies, they ought to endeavour to make the works of God manifeſt to poſterity, and by due care they might profit more than by any other means whatſoever.

The great Indian Nautilus is nearly of the ſame ſtructure with the Cornu Ammonis, and therefore I had once thought to give its figure in this place: but ſince it is found in many of the cabinets of the curious, and of the ſame ſtructure with this, I ſhall deſiſt from my intended purpoſe, and the rather, becauſe the celebrated Aldrovandus has left us a pretty neat and exact figure thereof.

Let it ſuffice, that I have annexed the figures of the two tubular Snails, or teſtaceous tubes already deſcribed, which afford an example, from which the manner of conſtructing all the ſhells of Snails may, in ſome meaſure, be underſtood. All the difference obſerved between them ariſes from the variation of their convolutions only: to which, if we further add ſome outward ornaments of ridges, hollows, windings, plains, tubercles, depreſſions, extenſions, impreſſions, and colours; and laſtly, that the cavity of the pillar ſometimes grows together entirely, as I have likewiſe ſometimes obſerved in the ſhell of the garden Snail; it is then eaſy to reduce all the geometrical figures, curves, oblique and right angles, in all kinds of Snails, to one ſpecies, that is, to an oblong tube, which is curved, curled, or bent in and out, and grows in this ſtate.

The tubular ſhell-fiſh before-mentioned*, exhibits the moſt ſimple articulation of all the kinds, for in their beginning they are ſtretched out, like a plain tube, Tab. VII. fig. v. *a*, or little inteſtine, and are turned or bent round moſtly near the end *b*. And hence ariſes that cavity, fig. VI. *c*, whereof I ſpoke, when I treated of the cavity of the pillar. But theſe tubular creatures grow together, ſometimes ten or twenty, in ſo perplexed a manner, that nothing certain can be diſtinguiſhed concerning them, ſince nothing appears to our view but ends or tops, windings and little apertures.

I ſhall further add, that almoſt all kinds of Snails and ſhell-fiſh are twiſted towards one and the ſame ſide; nor can many be found, at leaſt very ſeldom, the convolutions whereof go, Tab. VII. fig. XI. *a*, in a direction contrary to the others. In ſome ſpecies of oval Turbo's, and ſome others, this is ſometimes found; and ſuch ſhells, for this reaſon, that they are leſs common and more eſteemed, are carefully kept in the cabinet of the curious.

The little Turbo.

I found ſome years ago a ſmall Snail between the bark and wood of an old willow-tree, the ſhell whereof reſembled a ſea Turbo, and from a ſomewhat broad beginning, terminated Tab. VIII. fig. I. *a*, inſenſibly in a ſharp-pointed top. This Snail is never ſeen in the day time, except in rainy weather; it then always hides itſelf under the bark, or in other ſhady places, and reſting there, it faſtens that part of its ſhell by which the body creeps forward, to the wood, the other acute extremity being obliquely directed upwards. The ſhell of this Snail is likewiſe curled or convoluted in an inverſe manner; and what merits great notice is, that its genital organs are placed in the left ſide of its neck, in an order contrary to all other Snails. But I have ſometimes obſerved the convolution of the ſhell to be inverted in the Purple-fiſh. It is therefore probable that whatever Snails have their ſhell twiſted in an inverted manner, have likewiſe their genitals in the ſame ſituation.

I have very ſeldom ſeen this Snail with its ſhell larger than I have expreſſed it in the figure; nor have I found that part *b* of its body, which

* Theſe are called Tubuli Marini by authors: they are ſimple and plainly hollow. Some are ſtraited, and others ſmooth on the ſurface; ſome perfectly ſtrait, others twiſted at the end. They are found looſe on the ſhore, and lodged in ſolid ſubſtances. The animal within is a true Snail.

creeps therefrom, larger than there ſhewn: for when this part turns out, it carries its little ſhell like a pyramid obliquely on its body. It has four horns, whereof the two upper ones have their eyes in their extremities. The two lower do not appear ſo diſtinctly, being only two obtuſe or blunt little ſwellings. The two upper horns and the eyes are large, in proportion to the bigneſs of the creature. The aperture of its verge, through which it breathes, is likewiſe in its left ſide. Its ſhell is twiſted into ſeven ſpiral lines, and is adorned on every ſide with little ribs or ridges, ſo that, by this means, very beautiful wrinkles or folds appear in this ſhell, which has likewiſe its perioſteum to cover it.

The internal parts of this little creature agrees in general with thoſe of the common covered Snail. The parts of the jaws, mouth, and palate, and all the ſalival veſſels and the ſtomach, are alike in both. The brain lies on the gullet, and may likewiſe be beautifully diſtinguiſhed, but in its ſtructure it approaches more to the brain of the common water Snail, which I have repreſented in Tab. VIII. fig. IV. Its pointed liver fills the extremity of the ſhell, and, like the latter, it is likewiſe twiſted, but its ſtructure is glandulous. The orifices for the penis and uterus are opened in the left ſide, ſo that the penis, erecting itſelf, ſprings from a place directly oppoſite to that in the common Snail. But it appears from this perfection of the genital parts, that the creature, though ſo minute, has already attained its full ſize. The ovary likewiſe appeared to me pretty diſtinct. The purple ſacculus or bag, was likewiſe very viſible, as well as the little part in the form of a chain.

I preſerved this Snail alive ſome days, by giving it lettuce in a glaſs veſſel, into which I had poured alſo ſome drops of water, during which time it moved the whole day. At other times, when the weather is hotter, this ſpecies eat chiefly at night. In the month of June I found it under the bark of willows.

If its ſhell be viewed with a microſcope, the aperture, Tab. VIII. fig. II. *a*, of the inverted twiſt, through which the body paſſes, and the opening *b* of the pillar, and the ridges of the ſurface, or the ribs *ccc*, appear clearly to the eye.

The ſmall flatted Snail.

Under the bark of willows is likewiſe found another ſpecies of ſmall Snails, the ſhell, fig. III. *a*, of which is ſomewhat of a more ſimple ſtructure, and ſo thin that it is all over tranſparent. The Snail contained in this died for drought before I could diſſect it. Its ſhell was all tranſparent, by reaſon of its exquiſite fineneſs; ſo that the dead body of the Snail appeared through it, diverſified with ſome colours and ſpots.

The oval Snail.

In the ruſhy graſs of ditches, and on the water-lilly, when its leaves reach to the ſurface in rivers, there is found a certain ſpecies of Snails, which reſide there on account of the cool air and moiſture, where they may at any time ſeek out for their food: but they go to feed chiefly late in the evening and early in the morning, and in the heat of the day they remain quiet near each other under the ſhade. Their ſhell which they carry on their bodies, is of an oval figure, marked with many hollows or furrows, and adorned, Tab. VIII. fig. IV. *a*, with a perioſteum of a pale red colour. The hinder part is ſo tender, that when roughly handled, it is very eaſily broke, and this is rolled into a double ſpiral part *b*. The body of the creature that creeps *c* out from thence is marked with points or black ſpots, and in the fore part it ſtretches out two blunt or obtuſe *d* horns, under which are ſeen two others ſmaller.

In the mouth of this Snail is a pretty ſtrong tooth, which is extended into a horny little bone, and expands itſelf through the whole inward part of the mouth. The aperture of the verge is on the right ſide, and the orifices of the genital parts open at the ſame ſide in the neck. The ſtomach is of a pale colour, and is variegated with black points or ſpots; hence it appears upon the whole gray. The ſalival veſſels which run near the gullet under the brain are very remarkable and large, in proportion to the ſize of the animal, and are ſpeckled or ſpotted like the ſtomach. The liver is the ſame as in the common Snail. The heart is placed in the left ſide, and there lies the lime bag alſo, which is very large, and full of round white globules of various ſizes. The brain and nerves are like thoſe of the common covered Snail. The penis appears ſhort, but if the membrane, by which it is erected, be opened, it is found bent on the inſide like the tendril of a vine, and is ſeen to be really very long. The ſtructure of the uterus is the ſame with that of the common Snail; but on one ſide of it is a ſmall part that I never ſaw in that Snail. After this follows the yellow ſacculous bag deſigned for the glutinous moiſture; and at length the ſmall part in the form of a chain, which is very black like pitch. The purple pearl-eyed little knot appears half round in this Snail, though it is really ſomewhat oval. I could not diſcover more parts in this little creature, though I obſerved that it had the ſame muſcles as the common Snail; nay, that two of them were deſigned to paſs underneath through the brain, for the purpoſe of drawing in the parts before mentioned.

CHAP. XIII.

Of the garden Snail, the houfe Snail, and that of the fields or path ways.*

ALL the external and internal parts of the garden Snail, which is a handfome little creature, are the fame with thofe of the larger Snail, only that they differ a little here and there in refpect of ftructure and colour. Since therefore the difference is not fo great in regard to the reft, I fhall here briefly explain the only one that is in the genital parts. The aperture of the genital organs, Tab. VIII. fig. v. *a*, is placed in the neck, fomewhat lower than it is in the larger Snail. The uterus *bb* and its ligament *c*, and the bag which holds the glutinous moifture, are like thofe of the larger Snail *d*. There is, moreover, no difference in the chain-like little part *e*. As I began this inquiry in the month of June, which was indeed far advanced, the little eggs *f* were feen more diftinct in the ovary, near the extreme fpiral part *g* of the liver; thefe eggs were, in my opinion, to be carried from thence through the chain-like little part into the uterus, and to be covered all over with the glutinous moifture. The purple little knot *h* was of a colour almoft approaching to a pale yellow, and contained a ftronger fubftance than in the larger Snail. The other tube or pipe *i*, which in the larger Snail opens into the uterus, was in this ftretched out further, and the alcaline little bone was, in a fituation directly contrary, thruft into it. In the larger Snail, likewife, I have found this tube fometimes in the fame fituation. This little part was moreover formed, where in its beginning it is connected with the uterus *k*, in the fame manner as it is in the larger Snail. The imperforated appendage *l* of the uterus has likewife the fame ftructure, but is of a more gray colour: the tefticles *m* likewife, were like thofe of the covered Snail, but confifted of longer filaments, and were divided only into fix veffels. The alcaline little bone *n* was of a ftructure entirely different, and wanted thofe four little ribs, which I have before exhibited in the magnified bone of the larger Snail, but was very beautifully decorated with little holes, and little prominences that met all together. It was however full as big as the little bone of the other Snail, and may likewife be ftretched further out of the body, for it ftood on a longer little knot, the neck whereof was much longer, and likewife of a gray colour. The penis *oo* feemed longer and more acute, and I have here delineated its only mufcle, Tab. VIII. fig. v. *p*, which draws it in. This was placed in the fame manner as in the large Snail. Moreover, the common duct *q* between the penis and uterus did not differ in refpect to its ftructure. But this Snail twifted about the fharp end of its penis in the diffection, and curled it into various turns *r*, which I never faw fo clearly and diftinctly in the other Snail.

There is great difference between the manner of coition in the larger Snail and this of the garden; the penis of this latter is rolled out further, and is more erected and much longer; it has at its origination the fame glands the skin is provided with. The coition of the garden Snail continues longer than that of the larger Snail. And the whole penis of one Snail is put as far as its extremity into the body of another; hence thefe two penis's are fometimes feen, fig. VI. *a*, twifted together in a very wonderful manner. But this winding is not feen fo beautifully as I have delineated it, unlefs the Snails are drawn a little afunder; for then is perceived the wonderful manner whereby the penis of one Snail *b* rolls itfelf round the penis of the other, and enters into the uterus *c*, whilft the penis of the latter is, in its turn, twifted round that of the former *d*, and likewife put into the orifice of that creature's uterus *e*. But if thefe Snails are pulled away from each other at the time of coition, the whole penis's, long as they are, being drawn from the orifice of both Snails appear in fight, and each creature afterwards turns them in in a wonderful manner, and after a fhort time draw them back again into the body.

But as each Snail has its genital parts in the right fide of the neck, their heads are applied to each other crofs-ways at the time of coition, and confequently the body and horns of each Snail have a contrary fituation at that time. For in the body of the former Snail *f*, the opening and divifions of the verge whereby it draws the air, are vifible; but in the latter Snail nothing is feen of them *g*, for this Snail is placed in a different manner.

Thefe garden Snails are of the moft common kind. Their fhell is grounded on yellow, and is divided lightly by fpecial fmall furrows; it is alfo adorned with tawny or black rings, which furround it nearly in the courfe of the fhell's fpiral turns. It is alfo covered with a very thin membrane or periofteum, which is black or yellow in the fame places where the fhell itfelf is painted in that manner, and it likewife preferves its colour when the membrane is taken from it.

Each of thefe Snails has alfo four horns, of which the two upper ones only have eyes.

* The fpecies here meant by the author, is the common fmall painted Snail, which we find in hedges. We ufually call the larger brown kind the garden Snail, becaufe it is more common with us in gardens; but this the author calls the common Snail. This lefs being more frequent in the gardens of Holland, is the garden Snail of that country.

It

It was therefore an idle fancy in ſome perſons, to think that the Snail uſes its horns, as a blind man does his ſtick, that is, to find out the way it is to creep through, or to try and diſtinguiſh, by its touch, whether objects are hard or ſoft. The head of theſe Snails, in that part of it where the lips are ſituated, reſembles, in ſome meaſure, the head of a cat; and when well viewed, it appears like it in ſeveral reſpects more evidently.

The common houſe Snail.

The naked houſe Snail, which is found in moiſt cellars and about the tops of ciſterns, is naked and has no ſhell, but is covered with its skin only. In this particular it agrees with that part of the covered Snail, which creeps out of the ſhell. On the outſide it is provided with four horns on its head; the two uppermoſt whereof have eyes at their extremities, Tab. VIII. fig. VII. *aa*, which are ſituated a little within the margin, on that ſide which lies towards the eminence placed on the back. The two lower horns *bb* are ſmaller and have no eyes. There is further ſeen on its body, that eminence or velabrum *cc* which is fixed to the back, and runs along the reſt of the body; and the body is furniſhed with oblong, acute, and tender glandules, and variegated with black lines and ſpots. But the horns, head, neck, and whatever reaches beyond the eminence, are adorned with many ſmaller and more delicate glandules. On the right of the declivity of the neck appears an apperture *d*, through which the genital organs puſh themſelves.

The eminence on its back itſelf, is of a different colour from the reſt of the body, for it is adorned with chanelled or creſted little grains, and it is moreover very beautifully variegated with black ſpots. This is not common to all houſe Snails, for they differ much in colour. Towards the fore part, at the head, the eminence is looſe and free, but for the moſt part, it is kept very cloſe to the body, unleſs when any one provokes or vexes the Snail in that place; for then it raiſes and moves it different ways; and I have, for that reaſon, drawn it as elevated in the figure. On the hinder part, towards the back, the eminence is very ſtrongly joined to the body; but in its right ſide opens an aperture, Tab. VIII. fig. VII. *e*, whereby the Snail draws air and breathes, and diſcharges its fœces; for which uſes the verge is likewiſe appointed in the covered Snail, and with this verge the eminence agrees very much, ſo far as it is placed on the fore part of the body. The hinder part of the body is not very remarkable, only in reſpect of the different ſtructure of its glandules. Moreover, in both ſides of the body is obſerved a ſmall, black, unequal margin. In fine, there is on the hinder part, above the tail, a prominent ſubſtance *f* like a Cock's comb, which is indeed diſpoſed in a different manner in the field Snail. The Snail ſecretes a glutinous humour from this part.

If any one opens the eminence at the mouth of the air paſſage with a little pair of ſciſſors, he will ſee that the inward skin is made on the inſide like a net; which ſtructure ſeems to be produced by the veſſels diſtributed through it, as I have likewiſe before ſhewn in the verge of the covered Snail. This little net may be ſeen very beautifully through the aperture of the eminence on a clear day, when the Snail opens it; for the creature can contract it ſo cloſely, that not even a veſtige of an aperture appears. In the cavity of this eminence, on the left ſide of the body are ſeen the heart, which beats, together with its auricle and pericardium, and likewiſe other cavities through which the air paſſes. But when you remove this little net from its place, you will ſee a ſmall ſtone underneath, which is called, by authors, Lapis Limacis, the Snail ſtone, and is ſaid to ſerve for various uſes in medicine. This little ſtone may properly be called the os thoracis, or breaſt bone of the creature, for it is placed in the middle of the thorax and back. It is of the figure of a ſmall hollow, and ſomewhat long ſhell, fig. VIII. *a*. and being connected in its circumference with various membranes, and on the upper ſide with the little net, it is thus kept in its place. It is ſometimes obſerved to be altogether membranous, but ſometimes it is pretty thick and all ſtony, and it ferments with an acid; at other times, again, it becomes ſtony only here and there, and is obſerved to be interwoven *b*, as it were, with veſſels which are filled with ſtony little grains. Hence one may underſtand the manner of its production, which is from the coagulation of the ſtony particles; in like manner as is obſerved in the membranes which the covered Snail frames, when it lies ſome time at reſt. Theſe ſhelly ſtones are found in younger, as well as full-grown houſe Snails, and I have ſometimes found in the largeſt, very ſmall and membranaceous ones, interwoven with various petrified veſſels; and often in ſmaller ones, I have found them formed of ſolid ſtone. Hence I am inclined to think, that the Snails change this their little ſtone yearly, in the ſame manner as Craw-fiſh change thoſe two ſemi-convex and plain ſtones, which are likewiſe placed in their thorax, and are improperly called Crabs eyes.

Near the heart is obſerved a ſacculus calcarious, or lime bag, not much different from that which we have deſcribed in the large Snail. Afterwards the ſtomach, inteſtines, and genital parts preſent themſelves in the abdomen. The ſtomach is indeed pretty large and ſtrong, and conſiſts of three diſtinctly viſible coats. The innermoſt is wrinkled into plaits, and is of a yellow colour; the middle one is muſcular; the outermoſt is ſomewhat corrugated or rough, with very beautiful partitions, eſpecially when the ſtomach is empty. Directly before are ſeen the ſalival veſſels, which, as well as thoſe out of which they ſpring, are ſhorter than in the larger Snail, but they are of the ſame texture. The inteſtines paſs twiſting or winding

ing through the liver, which is placed between them, but they are much leſs rolled and turned in this than in the larger Snail, ſince they are ſtretched according to the length of the body, and are not obliged to follow the convolutions of a ſhell. The liver is divided into many lobes, and conſiſts only of minute glandules.

The genital parts in this Snail are worthy of particular notice, ſince they fill the whole belly: but I ſhall treat of theſe hereafter, when I ſhall briefly deſcribe the parts of the head, neck and breaſt. The head preſents a tooth, viſible in the mouth like that of the larger Snail, and all the parts of the mouth are alſo formed in the ſame manner as we have there related. The brain likewiſe, the ſpiral marrow, and the nerves, which are placed in the neck, do not differ much, and are eaſily diſcovered. The muſcles which move the upper horns inward, are much more brown or blackiſh than in the larger Snail; but the reſt, and likewiſe thoſe which paſs through the thorax, have ſome fleſh, as well as their white tendons, and are both inſerted in the ſkin, which is very thick, and where the eminence lies: nor are there any bones in the Snail, in which the muſcles ſhould be inſerted. A muſcle is therefore here inſerted in a muſcle, and one dilates another, which is a very admirable thing to ſee in animals.

The organs of generation in this Snail, open by three diſtinct apertures in the neck, Tab. VIII. fig. IX. *a*, which unite in one paſſage on the outſide. The firſt opening is peculiar to the penis *bb*, the ſecond to the uterus *cccc*, the third to the purple bag, which is very ſhort in this Snail. The penis is ſtrong and very nervous, and it lies in a little kind of a purſe, which may be diſtended by the breath, that the penis may roll itſelf out from thence. On the hinder part or ſide of the penis iſſues a ſmall filament *e*, which is connected with that of the uterus *fff*. This ligament of the uterus abounds with many granules, which are white, and unequally divided; thoſe, at firſt ſight, I took for the ovary in the larger Snail, thinking that the little eggs were conveyed through certain hidden channels out of it into the uterus: but I now obſerve, that it has a peculiar kind of tube in this Snail, which opens into the hinder part of the cavity of the penis, and conveys its matter into it. The uterus wraps itſelf round this ligament, and is greatly ſtrengthened by its connexion therewith, though this connexion is formed in the beginning only by ſmall intervening membranes.

The uterus in the Snail which I diſſected, was very much diſtended and ſwollen *gg* with little eggs; nay, its texture ſeemed more ſtrong and firm, than when nothing is found in it. On the hinder part lay the glue-bag *hh*, very much dilated and expanded into lobes, which were again ſtudded in a peculiar manner. When I viewed them with a microſcope, I obſerved, that they were all full of very ſmall ſpheroidal globules, whereof ſome were bigger than others. The chain-like little part *ii* was ſtretched ſtraight, or upright enough. The ovary was fallen down *k*, and deprived of its eggs, ſo that nothing was left in it but the membranous incloſures. All the eggs, in my opinion, had deſcended through the chain-like tube into the uterus, and were to be immediately there covered with moiſture, by means of the ſaculus that ſecretes that fluid: this I ſhall explain more at large, when I ſhall ſpeak of the field Snail. Nor did the eggs, notwithſtanding, fluctuate freely in the uterus, but they all lay firmly fixed on one ſide, which makes me ſtill doubt to advance what I have ſaid of the ovary and eggs as true and certain. But I hope theſe things will hereafter be made plainer. I ſhall therefore proceed to the field Snail, the anatomy of which will throw great light on this matter.

Of the field or path-way Snail.

The common Snail of the path ways and fields differs from the houſe Snail, chiefly in reſpect of the ſtructure of its external ſkin, and in a peculiar kind of verge which ſurrounds its body; to which may be added, the fiſſure that is in the extremity of its tail, out of which a certain glutinous humour is ſecreted: but there is no difference in the internal parts. I have delineated the field Snail, which I here exhibit, in the form it has when contracted. Thus its two largeſt horns, Tab. IX. fig. I. *a*, may be ſeen, except a ſmall part thereof, which is covered by the eminence or velabrum. On the right of this velabrum is ſeen an aperture *b*, whereby the Snail draws the air and diſcharges its excrements: the ſame may be obſerved likewiſe in the houſe Snail. In the cavity of the eminence, the ſkin is alſo white and reticulated, as it is in the houſe Snail. The external texture of this eminence conſiſts of fine glandular granules, or little grains, which are far from being orbicular; they are ſtriated as it were, and rendered unequal by ſome tubercles, though theſe ſtriæ or furrows are not as remarkable in this as in the houſe Snail. The reſt of the body is furrowed as with pretty conſiderable wrinkles; hence it is that many glandular protuberances appear in it, which are of a triangular form, and riſe up obliquely, and are divided *cc* by many ſmall glands. The body is, moreover, adorned with a full, or gloſſy, red verge *dd*, which is beautifully divided and ſubdivided by black furrows, ſome of which therefore are more conſpicuous than others. This Snail can extend itſelf to three times the length that I have here repreſented; and then the diviſions of the ſkin before deſcribed acquire as it were another form, by the force of its expanſion. The whole body is of a deep brown, mixed with a ruddy colour; but theſe Snails differ very much with reſpect to their colour.

As its internal parts are organized, and circumſtanced much in the ſame manner as in the houſe Snail, I ſhall now briefly deſcribe only the ſtructure of the genital organs, and add the conftruction of fome of the internal parts, which I have here alfo delineated. The genital organs are thruft out of the neck, in the fame manner as in the houfe Snail, and are found to be likewife placed behind the parts of the palate and mouth, Tab. IX. fig. II. *a*. On each fide the larger horns *bb* may be feen when drawn in; they appear under the divided skin of the head. Behind the proper parts of the mouth, and above the gullet *d*, is placed the brain *e*, which is formed of two fmall parts like globes, applied clofe to each other. Immediately after appears the origin *f* of the ftomach, together with the falival veffels *gg*, which are here reprefented as clipt or cut off near the gullet. After thefe are obferved two glandular corpufcles *hh*, from which the falival veffels arife. Then at length is prefented to our view the ftomach, with its veffels *i*, which are of a pure white, like the colour obferved in the inteftines *kk*. The windings of the inteftines furround the liver *lll*, which confifts of fmall glandules, equally divided and interwoven with very white veffels. It fends forth the gall-bag *m*, which is large, and difcharges itfelf into the fmall guts that are next to the ftomach.

The beginning or rather end of the genital organs is feen in the skin *n* of the neck, and their mouth or opening appears there in the outward skin; which, however, I have not exhibited in this place, that the other parts might be the more diftinctly vifible. The firft thing that prefents itfelf is the penis *o*, which, being twifted like a tendril of a vine, opens with a kind of tube *p* into the cavity of the uterus. Nothing of this kind is obferved in the houfe Snail, but in the covered Snail there is likewife a common duct, and the penis is extended longer. Behind the penis is feen a remarkable pear-fhaped bag *q*: this is the purple-bearing bag; it is very large in this Snail, and contains a delicate juice. It opens by a fmall tube *r* into the cavity of the skin of the penis, by means of which the latter erects itfelf.

The origination *s* of the uterus is pretty thick and ftrong, and after it grows fmaller *t*, it twifts and bends itfelf, and goes into the body of the uterus *uuuu*, as it does in many other Snails. But the ligament of the uterus is not feen in this; its place is occupied by feveral whitifh veffels, which are connected *xxx* by a fmall kind of membrane, that ties the curled windings of the uterus. About the end of the uterus, where the bag of glutinous moifture *yy* is joined to it, is feen a place where the chain-like tube is inferted, or fixed in the uterus: nay, it further appears, how this tube runs through and over the liver, and under the fmall guts *α*, and is connected with the ovary *β*, which is here empty. This ovary is divided into two parts, as it is in other creatures. The divifion, however, is not fo remarkable in thofe Snails, which have not exercifed venery, as it is in the ovary, which I here exhibit alone, fig. III. *a*. I therefore reprefent this ovary big and expanded, as I think I faw it fome months after coition. For it is then obferved, that this little part confiderably increafes, Tab. IX. fig. III. *a*, and that the eggs *bb* are made vifible therein. I have likewife obferved this increafe in the ovary of the fhelly Snail. But the eggs, it feems, are afterwards difcharged out of the ovary, and defcend through the chain-like little tube *c* into the cavity of the uterus, to the hinder part of which the former is joined, fig. II. *z*. But as the paffage of the eggs is fo near to the bag of glutinous humour, I therefore think, they are there covered over with a little of it, and that when they grow larger, they get more of it, and, at length, attain their full bignefs in the uterus. But I could never hitherto find eggs in the chain-like little part, as I have already mentioned in the defcription of the houfe Snail; nor could I fee that they are conveyed through it. I fhall therefore defer advancing this opinion as an undoubted truth, until I fee it myfelf; though I think, at the fame time, the matter may moft probably happen fo. The heart likewife is feen in its natural fituation *γ*, as alfo the manner in which it is furrounded by the bag *δδ* of calcarious or limy matter.

C H A P. XIV.

Of the common water Snail, alfo, of an uncommon and viviparous kind of water Snail; and of the flatted water Snail, and the mufcles of the river Vecht. Alfo a remarkable obfervation on the common Snail.

THE common water Snail, which I find every where at the edges of ditches in Holland, differs much both from the common covered, and from all other Snails. It is diftinguifhable, not only in regard to the outward skin or fhell, but alfo with refpect to its eyes, and the apertures both of the verge and the genital organs, which are all confpicuous on the outfide. There is alfo a ftill greater difference in the internal parts; all which I fhall now briefly enumerate.

The fhell, which is in the form of a fpheroid in the large Snail, is in the water Snail rolled in an oblong form like that of the Turbo, Tab, IX. fig. IV. *a*. But there is ftill a greater difference in its eyes; for as the latter in the common Snail are at the ends of the horns; on the contrary, they are found in this aquatic

aquatic or water Snail, to be fituated at the bottom or bafis *bb* of them, but they are not provided with any vifible mufcle to move them. Even the horns themfelves, which end in fharp points *cc*, are only weakly drawn in occafionally in order to become fhorter.

In fome of thefe Snails, I faw with amazement that there were two eyes, placed near each other on the right fide of the creature, each of which was provided with its own proper chryftalline humour. This, I think, is very remarkable, and ftrongly demonftrates the manner wherein the eyes may be multiplied in infects, as I fhall hereafter demonftrate, when I fhall treat of Bees. The nerves of the eyes in this water Snail are lefs vifible than in the common kinds; nor do they arife immediately, as is faid, from the brain, but from a little nerve which lies towards the fore parts of the head. In other refpects the eye itfelf does not differ from that of the covered Snail, only that it is bigger, and in a manner pear-fhaped, or like an onion. The chryftalline humour is likewife larger in this, however diftinguifhably lefs the little creature may be in itfelf.

The opening *d* of the verge is very worthy of confideration, and has divers mufcles, by which it is dilated and contracted. The Snail fometimes gathers this aperture into an oblong tube, and ftretches or protends it above the furface of the water, in order to draw in and expel the air. This may not only be feen but heard alfo, by the noife which the Snail makes in moving the water. Nay, by the affiftance of this aperture, through which the air is conveyed into the inmoft furface of the membrane of the verge, and into the cavity of the body itfelf, the Snail makes a beautiful figure fwimming in the water.

This creature can likewife immerge or dive to the bottom of the water, if it compreffes the internal air. This is effected in the fame manner as when the air is compreffed in a glafs with water in it; for little perforated glafs globules fwim at firft in the water, by the affiftance of the air contained in their cavity: all thefe little globules fubfide as foon as the fmall quantity of air contained in them is condenfed; which happens by the common preffure of the air, that is above the water in the glafs; but they emerge or rife again to the furface, as foon as the finger or any thing that ftopt it, is removed from the mouth or orifice of the glafs. This is a pleafant experiment, and I have found it very true, according as it has been defcribed by Cornelius Confentinus, in his platonic circumpulfion.

In the fame manner does this Snail fometimes dive under water, and again fwim to the furface, by properly managing the quantity of air in its body in fuch a manner; the latter, being as heavy as the water, it can difficultly be fupported on the furface, and is again depreffed to the bottom by the leaft compreffion of the internal air. But when the Snail expels all the air out of its body, which it will do if it be pricked with a fharp-pointed little needle, it will not then be able to fwim up to the furface of the water, but by creeping flowly. So that from hence it is probable this creature would die, if any thing like it fhould happen in dirty or miry ditches; fince, in that cafe, it could not reach the furface of the water, until after fome days, and would therefore be fuffocated for want of refpiration.

There is likewife a great difference, with refpect to the external skins or coats of the genital organs; all the parts of generation in the covered Snail iffue out of one opening only, whereas in this aquatic or water Snail, all thofe parts and the entrances or mouths of each are diftinct. The penis indeed rolls out and erects itfelf from the neck through a peculiar aperture. Tab. IX. fig. IV. *e*. But the opening of the vulva is difpofed, by the wife Architect, immediately under the tube of the verge *f*. The verge itfelf likewife differs greatly from that of the common Snail; it is fmaller, more hollow, and capable of greater motion; but then it is fitted on the infide to every part of the extremity of the fhell *gg*, in the fame manner as it is in the common Snail. The tooth *h*, and little tongue which is feen under it, are of the fame texture in this as in the common Snail; unlefs that the tooth it more equal, and not divided into fo many confiderable notches.

The internal parts likewife differ much both in colour and ftructure: but the greateft difference is in the ftomach, which is membranous in the covered and other Snails, as it is in men and in quadrupedes; but in this water Snail it is of the fame ftructure in all refpects with that of the Hen or Cock kind; fo that one would think the real ftomach of a Hen is here reprefented, without any difference, but that it is much fmaller. Moreover, the colour of the craw or crop is a dark or obfcure gray. The gullet of this paffes likewife the chink or crevice of the brain, which is a very agreeable fight in this admirable creature. For fince the fwellings or productions of the fpinal marrow, are, by the addition of a certain heterogeneous yellow matter, here diftinguifhed, all thefe parts are therefore the more diftinctly vifible. Hence it is, that one may, with greater eafe and certainty, eftablifh the anatomy of the water Snail, than that of the covered Snail; for in the former are many coloured parts, by means whereof the mufcles, and many other parts, efpecially thofe of the palate and mouth, may be eafily diftinguifhed.

The falival veffels of this are like thofe of the common Snail. The liver is likewife compofed of vifible glandules, and rolled into the like fpirals. The heart alfo, with its pericardium, is placed in the fame order. The veffels on the verge, on the contrary, are not fo diftinctly vifible. The lime bag is of a pale orange colour. All the mufcles are inferted in the outer part of the fhell and its pillar.

The organs of generation likewife differ: the penis in this water Snail is very broad; it is like

like an oblong tongue, and refembles, in fome meafure the penis of a Drake. The mufcles likewife are ftronger, and more diftinct and numerous than in the common Snail. The uterus is divided into three parts, and opens with two mouths into another, which is under the verge; The firft part is of an afhy gray colour, and like the belly or rough tripe aforefaid in beafts that chew the cud; then the uterus becomes more glutinous, and receives fome expanfion from the chain-like tube; to which likewife adheres the bag of glutinous moifture, and alfo another little part which may be taken for the ovary. Moreover, the chain-like tube is larger here, but where it is connected with the ovary and liver, it is of the fame ftructure as in the covered Snail, unlefs that thofe white ftuds, which I obferved in the covered Snail, are of a yellow colour in the water one. The purple little knot is alfo here of a full orange colour, and opens into the vulva by a fingular kind of tube, as in the naked Snails. I have not feen the egg, but I faw fome relaxed, round and tranfparent little parts in the body, which I thought to be properly glandules. Under the organs of generation, near the ftomach, I obferved a certain ftrong plait or fold of veffels, of which a confiderable number were detached towards the liver.

The ftomach, when opened, very beautifully exhibited its two ftrong mufcles, and in its cavity were found fome hard feeds of water plants; by the help of thofe the Snail probably grinds its food, as Hens and Pigeons do with little ftones, bits of lime, and other things which they devour. I have been informed that a Duck or Drake has fwallowed a piece of gold, called a piftole, and diminifhed it by attrition to fixteen grains; and hence arofe the ftory that the Oftrich can digeft iron, as Harvey well obferves.

The food which thefe Snails moft eat is water plants. I have maintained them for fome days with lettuce, with which they were fo greatly delighted, that they eat all the larger leaves of it when they had been fome days without food. But they were then continually thrufting out their tongues, from which I concluded that they were hungry. I likewife fed the Snails fometimes with ryebread, which they would greedily feed on, if it was firft foftened with water. At thefe times may be very diftinctly feen the manner of their eating, efpecially if the bread be cut into fine thin pieces. The next day, after I had laid this bread before them, they prepared for generation; fo that I fhould conclude from thence, that bread yields them the moft copious and effectual nourifhment. The Teredo or Worm which eats fhips bottoms, is alfo delighted with bread.

On the fhell of this kind of Snail, I have fometimes found a great number of eggs, which were laid by another Snail of the fame fpecies. They lay inclofed in an uniform, oblong, and pellucid glutinous fubftance, and they were likewife tranfparent as chryftal; but after a few days there appeared in the middle of them a very fmall gray Snail, which continually rolled or turned about in the fame manner, as a bit of wax does in a bottle full of water, when the bottle is gently turned up or inverted. Almoft in the fame manner did this water Snail turn fpontaneoufly in its fhell, and fwimming in a limpid humour or moifture, feemed to adhere to no place. The third day after thefe eggs were laid, the Snail contained in them began to grow yellow, and afterwards they became gray.

This Snail fwims with the fame body, Tab. IX. fig. IV. *ii*, with which it iffues out of its egg. This is done in the manner following: firft, the Snail lies upon its back in the water, and turns the whole length or level of its body againft the furface of the air that preffes on the water, and having afterwards firft bent its whole body, it moves it forward in the fame manner as the common Snail does; and by this means, fwimming in the water, this creature goes forward, though very flow, and affords a very agreeable fight. But left the heat of the fun fhould injure it, the little creature fecretes a quantity of mucus or glutinous humour out of its body, by the help of which it is defended from the injury of the diurnal rays, and is rendered more fit for fwimming; and it can move and turn itfelf to all parts in the water as occafion requires.

In order to diffect thefe Snails, it is neceffary firft to take them out of their fhells; then they will die in two days, and are fo much fwollen with the water which they imbibe, that their organs of generation fometimes come naturally in fight, and their diffection may eafily be perfected. But if you wound thofe parts which moft abound with the glutinous humour, nothing can be done to any purpofe afterwards.

I have delineated this Snail in the form it is in when it creeps near the fide of the glafs in the water, and afcends to the furface; and there, having lengthened the aperture of its verge, Tab. IX. fig. IV. *d*, as into an oblong tube, and ftretched it out of the water it breathes.

The wonderful viviparous chryftalline Snail.

The miracles which I am now going to advance of this water Snail feem fo incredible, that I fhould not wonder if they fhould be deemed impoffible, or reckoned among the fabulous tales of the poets metamorphofes. For my own part, though I faw them, I was fo aftonifhed on this occafion at the inexhaufted fund of wifdom manifeft in the works of God, and his admirable art and immenfe power, that I cannot fince help thinking on them every moment. I thought I had already fo accurately fearched into the whole nature of Snails, that I could at length form many remarkable and certain obfervations, and from thence ftrike out fome general rules. But the further I advance in inveftigating the wonderful works of God,

God, the more and more I find they all as far exceed the bounds of human ingenuity and underſtanding, as mortal man, who in reality is nothing, is from being able to diſcover fully the infinite and incomprehenſible perfections of God.

The water Snail, which I here exhibit, Tab. IX. fig. v. *a*, naked, without a ſhelly covering, is found in great quantity in the ditches of Holland, and in large freſh-water rivers; it lies moſt commonly in the ſandy fords or ſhallows of the latter, or where there are any ſtones. It creeps in ditches near and among the water plants, and in mud, which it takes as food; and alſo in white clay, in which I firſt found it. Hence it becomes dirty, and is often ſo covered with a cruſt of filth, that all the beauty of its ſkin or covering is almoſt loſt. I have therefore broke off the ſhell from the body of the creature, and only repreſented the Snail without it. But becauſe the ſhell has alſo a ſingular and remarkable ornament, and exhibits ſomething truly worthy of obſervation, I ſhall afterwards delineate it in the manner it was found, whole, and without any imperfection in the uterus, and appeared under the microſcope. Though I have found in rivers ſome of this kind of Snails, which were leſs than thoſe which I exhibit in the figure, and had little dirt upon them, yet I never was ſo happy as to ſee the beauty of their ſhell wholly free of filth.

The things that demand notice on the outſide of this Snail, are the head, Tab. IX. fig. v. *b*, its horns *cc*, the eyes *dd*, the aperture of the uterus, the branchiæ or gills *f*, the verge *g*, the convolution or winding of the body *h*; and laſtly, the verge, which ſerves as a foot *iii*, whereon is placed the operculum or cover of the ſhell *k*. The head *b* is diſtinguiſhed from the heads of all other Snails, becauſe it is ſtretched more out of the body, and is more viſible; nor is it at any time drawn back to the inſide, but only ſhortened a little by the wrinkles of the ſkin. In the fore part is ſeen a ſmall aperture, which is the mouth; the horns *cc* are ſharp at their extremities; and at their root or baſis, where they ſpring on each ſide of the head out of the body, are fixed the eyes, which are placed ſomewhat higher than in other water Snails, and therefore agree in ſome degree with the eyes of ſhelly or teſtaceous animals. All theſe parts are very beautifully variegated with yellow ſpots on a black ground. On the right ſide of the uterus or vulva, is ſeen an extremity or edge, which the Snail ſometimes protends out of its ſhell under the verge. It is of a muſcular texture, and may therefore be expanded and contracted at the diſcretion of the Snail. This is the reaſon why I firſt took it for the aperture of the verge. Above the head are ſeen five appendages under the verge, which, I think, are the branchiæ or gills. The verge very nearly approaches to that of other Snails; but it has not ſuch a ſtrong and remarkable motion, though it is of a tougher, more firm, and more tenacious texture. The convolution of the body is the ſame as in other Snails.

The verge, or loweſt part of the body, whereby the Snail creeps, is more worthy of notice; for the operculum or cover is annexed to it. This operculum is neither bone nor ſtone, but approaches rather to the nature of claws or talons; it is therefore in the purple Fiſh kind, called the unguis or claw, and the unguis adoratus; becauſe when burnt it ſmells like caſtor or beaver, and is uſeful in the ſuffocation of the womb, or fits of the mother. If the operculum or cover of the Snail whereof we here ſpeak, be burnt, it has no diſagreeable ſmell. Its ſtructure is elegant: it conſiſts, as it were, of many rings, ſomewhat round, and differing among themſelves principally in the brightneſs or obſcurity of their colour. On the inſide it is hollow like a ſhell: the tail of the body, annexed to this cover, is fixed thereto with ſtrong muſcles; by the help of which the operculum or cover may be bent, folded, nay, complicated towards the mouth and horns, when the Snail betakes itſelf to its ſhell; and by means of this, as it were, little door or entrance, which it carries about it, it ſecurely hides itſelf in its ſhell, ſafe from all common dangers. This the Snail does as ſoon as it perceives the leaſt unuſual motion in the water, for I never knew a more timorous creature than this. It naturally creeps very ſlowly, and ſwims in the water with its body oppoſite to the ſurface of the air, as I have before related of the common water Snail.

Theſe are the external parts of this Snail; but the internal parts that we have obſerved in it are indeed ſo many miracles, ſo many ſtrange and unheard of things, as probably never, hitherto, came into the mind of any perſon. I therefore invite and require all atheiſts, who do not ſcruple to aſſign the generation of ſmall animals to accident or chance, to this ſplendid entertainment, that they may learn to give the praiſe and glory to God alone.

When one attempts a diſſection of this Snail, it immediately draws itſelf ſo much back into its ſhell, and preſſes its operculum or cover down ſo cloſely, that one cannot put the point of a little needle into it. You muſt therefore break open the ſhell, which is very firm, with a flat forceps, and take the Snail out with your hands. Then it will be obſerved that its muſcles are ſtrongly inſerted in its ſhell, and principally in the foremoſt or anterior part of it. Whilſt this Snail lives, its diſſection can ſcarcely be performed, ſince it bends or winds its operculum or cover, Tab. IX. fig. VI. *aa*, againſt the fore parts of the body in ſuch a manner, that the former is doubly folded; beſides, both the mouth and horns *b* are in ſome meaſure drawn in.

The diſſection ought to begin next to the vulva *c*, and the verge ſhould be opened there with a little pair of ſciſſors; after which four different

different parts come at once in fight; thefe are a fmall margin very beautifully folded *d*: the end of the inteftinum rectum, or ftraight gut *e*; then the branchiæ or gills *f*, fome of which appear out of the verge in the former figure: and at length the uterus *g*, which I have here delineated as diffected and opened together with the living fœtus contained in it; for the young are brought forth alive by this Snail.

The verge has not a fingular or remarkable aperture as in the other land and water Snails, but the whole is almoft open on every fide: the Snail however knows how to move the mufcular parts of the verge, and to fwell them out of the fhell in fuch a manner, that by this means it draws the air into its cavity; and this air is afterwards expelled from thence again, when the Snail hides itfelf in its fhell. Thus may this fmall complicated margin be very eafily feen; the doublings or winding plaits or wrinkles of it arife, in my opinion, from the bending and contraction of the body. If this little part *d* be diffected, it appears to be only a congeries or heap of tranfparent, chryftalline, and equal globules, which are of a ftony nature, and make a crafhing noife under the diffecting knife. The horns, the upper furface of the mouth, and many other parts of this creature become petrified, and therefore alfo make a noife like fand, when they are chewed a little in the mouth. I mixed fpirit of vitriol with them, and it caufed a very ftrong fermentation.

This firft obfervation is, therefore, very fingular, and merits particular confideration. We fee how the omnipotent God could frame a little being, which confifts, as it were, of fmall ftones, and yet can move, agitate, contract, draw in and extend thefe its parts; becaufe mufcles and their tendons are inferted in and run through them. But who can defcribe how the veins, arteries, and nerves are there interwoven and difpofed? Nobody truly, but He alone who made all thefe things. That congeries of chryftalline globules, in particular, which is fo copious in the horns, that one can hardly find a place wherein the parts aforefaid may not be conceived to be fituated; fo that even from thence it appears clearer than the light at noon day, what exquifite arts and unheard-of miracles the moft fagacious Architect has hidden in the immenfe volumes of his works.

If the inteftinum rectum or ftraight gut *e* in this Snail be opened, it is ufually found to be full of an earthy gray fubftance, and divided on the infide by many membranous and nervous partitions or inclofures like little valves, and grows larger and larger continually, until at length it paffes the liver and fmall guts, and ends in the ftomach, which feems to be like a fmall tube or pipe. The excrements which this Snail throws out, are a congeries of oval particles, linked or joined together, fuch as are found in the inteftines themfelves.

The parts which I call the branchiæ or gills, Tab. IX. fig. v. and vi. *f*, are likewife very wonderful; they are difpofed in a neat order, they are of equal length, and are placed at the fides of the inteftinum rectum or ftraight gut, which they accompany for a great way into the inflexion of the body. If you view them with the affiftance of glaffes, they refemble a comb with broad teeth, though in foftnefs and delicacy they are like little membranes. At firft I thought that thefe little parts were membranous expanfions of the uterus; but from their fituation and ftructure I afterwards found that they agreed more with branchiæ or gills.

The uterus, which, as we have faid, is reprefented, fig. vi. *g*, open here, is fituated in this Snail where the ftraight gut is feen in the common covered Snail. When I opened it gently, I immediately met under its upper coat, which it has in common with the coat of the verge, a congeries of oblong little parts, fig. vii. *a*, which were very numerous, and differed fomewhat in their length, figure, and thicknefs; and when I removed them from their places, I found they were all alive, and were fo many living little Worms, as there appeared particles of that fort. On the infide of thefe Worms was feen an oblong tranfparent afh-gray coloured furrow or ridge. When I began to diffect one of thefe Worms, two, nay three, and fometimes four inclofed Worms of the fame kind iffued forth *; having almoft the fame figure, that is, a thick head, fig. viii. *a*, and fmall tail *b*, like young Frogs or Tadpoles. The former Worms indeed moved fomewhat flowly, but the latter being put into water, fwam very fwiftly, and very ftrongly twifted about their little tails. I muft confefs the fight of thefe aftonifhed me, as I never expected to have met fuch, and fo many miracles in one little creature, or that I fhould have been fo well convinced of my own ignorance and blindnefs in a fingle fubject.

All thefe Worms exhibited a roundifh little part, tranfparent through the middle of their body; but at the tail appeared fome foft little points almoft like hairs. I could not find any excrements in them. The little creature itfelf, viewed in the fun with a microfcope, feemed to confift entirely of fmall grains of fand. When I had afterwards taken all thefe parts from their places, a new miracle prefented itfelf to me: I obferved that the whole tube of the uterus likewife confifted of chryftalline little ftones, which were as numerous and as thick and clofe together, and difpofed in the like order as I have before related they were about the fkin, the complicated margin and horns. Hence I really think that this little creature may be properly compared to the coralline cruft which furrounds hard coral; for

* The Eels in pafte are in this manner viviparous, and there does not appear to be any diftinction of fex in refpect of the produce, for all are bearers. The late Mr. Sherwood has given an account of this to the Royal Society, the truth of which I know, having made the experiments with him.

the ſkin which covers the branches of corals, is almoſt of the ſame ſtructure, and may likewiſe be eaſily ſeparated from the hard coralline ſubſtance underneath. Nay, the ends or tops of coral are alſo of the ſame ſoftneſs; and I have found them ſtill tender after the coral had been out of the water ſome months: this I have before obſerved in the letters that I wrote on coral. In the common water Snail I likewiſe ſaw here and there ſome little round chryſtalline parts, which I think were likewiſe globules of ſand of the ſame nature. In the ſtraight gut of that Worm, out of which iſſues the Gad-fly, I obſerved ſomething like this, as I ſhall deſcribe and repreſent when I come to its hiſtory.

When I afterwards opened the uterus, I was more aſtoniſhed: I found a ſmall Snail in it *, in every reſpect perfect, which had already broke out of its membranes, and ſhewed the ſame diſpoſition and the ſame manners with the larger one its parent. Thus I learned that this little creature brought forth young Snails alive, as big as common peaſe, Tab. IX. fig. IX. *a*, which had their ſhells and coverings pretty hard; and that they were likewiſe complete and perfect in all their parts.

This ſhell, fig. X. *b*, afforded ſo beautiful an appearance under the microſcope, that nothing like it can be imagined. It was twiſted into four ſpiral parts, whereof the innermoſt diminiſhed its windings by degrees, until it ended in a pretty blunt point, almoſt reſembling a top. Moreover, the coat was covered with a perioſteum, and was very elegantly and neatly adorned with ſeven rows of briſtly hairs *c*, *&c.* Some black ſpots were here and there likewiſe ſeen, which were produced from the tranſparent body on the inſide. It was further divided by many ſpotted or ſpeckled little lines and other furrows; and alſo by little ribs that were notched and full of filaments; all which I have not delineated, leſt the figure ſhould have grown too big: nor have I leiſure enough at this time to enter upon ſo many things.

Theſe things convince me moſt clearly, that the ſhell or ſtony covering of the body is the Snail's real ſkin; ſince it has, even in the uterus, not only its own proper coat, but its hair. We are taught from thence alſo, beyond contradiction, that all theſe hard ſubſtances are nouriſhed and ſuſtained as well as the Snail's ſofter parts. For which reaſon the ſtony chryſtalline little grains before deſcribed, are fewer and ſmaller in the young and tender Snail than in the more grown one.

I find this ſhell, together with its animalcule, free and diſengaged on every ſide in the uterus, and not involved or rolled in ſuch coats as form the ſecundines. Hence one might, in ſome meaſure doubt whether this part, which I call the uterus, were not rather the œſophagus, and that therefore this animal had been only devoured by the Snail. But when I diſſected another Snail, I found twelve perfect eggs therein, ſticking in the uterus; each of which had its little navel-ſtring; Tab. IX. fig. XI. *aa*, and ſome of them had two *bb*. The ſtrings were ſomewhat broader near the egg, but where they were connected with the uterus, they were like a ſmall filament. They adhered almoſt in the middle of the uterus to a ſmall ſeam or ſuture.

The ſix firſt eggs, which are placed in the fore part, each contained a Snail, however ſmall, with its ſhell and food; the little body of this Snail lay extended out of the ſhell among the alimentary ſubſtance. The firſt egg had a larger Snail, but the ſecond, third, fourth and fifth a ſmaller. In the ſixth I only ſaw a ſmall point, the ſhell whereof was not yet conſpicuous.

In the other ſix little eggs, which were ſomewhat ſmaller than theſe, there was nothing to be ſeen, becauſe their tenderneſs made them tranſparent, and they were of one colour. On opening, them I found that there was a more tenacious liquor contained in them than in the former.

The ſix foremoſt eggs were as big as common peaſe, and were inveſted with a very tender and fine chorion and amnion, through which one might ſee the Snail within *ccc* languidly moving itſelf. Moreover, the whole amnion was filled with the moiſture beforementioned, which is the creature's true nouriſhment; and the Snail likewiſe ſwam in the amnion, as the human fœtus does in the mother's womb. As the Snail grows bigger, this humour is diminiſhed in proportion.

When I had broken the membrane of an egg which contained one of the ſmalleſt Snails, I found that the creature taken from thence, Tab. IX. fig. II. *d*, was as big as the head of a common pin; but it did not move out of, nor go into its ſhell: for its muſcles were yet too tender, and ſome of its parts had been probably broken off.

If this egg was raiſed or lifted up by its ſtring, the Snail within remained in its ſituation without motion; but when the egg, which lay out of the uterus for one, two, or three days, was thus kept ſuſpended by its ſtring, then the Snail within fell to the bottom of the membrane *e* which conſtituted the egg. Hence one may conclude with certainty, that the cluſter of veſſels was broken on the inſide, though it could not be ſeen, becauſe all things are here limpid, white, and very tender. The humour or fluid itſelf, that is, the nutritious juice wherein the Snail ſwims, is limpid, though it ſtill approaches ſomewhat to the colour of whey, and when put into the water it becomes more thick or muddy; but if it has remained in the water ſome days, then it expands

* Our countryman Dr. Liſter has diſtinguiſhed himſelf on the ſubject of this viviparous Snail. His obſervations in general agree with thoſe of this author, for truth is the ſame in whatever language it is written.

pands itfelf like glue, and at length it becomes clearer by the addition of the imbibed water.

When I placed this little Snail under the microfcope *d*, I faw its eyes very black like pitch, fig. XII. *aa*, but the reft of its body was colourlefs, or for the moft part white; the horns *b* are fomewhat blunt, the mouth *c* is open, all the reft of the body *d* is ftretched out of the fhell; I found the operculum or cover *e* annexed to the hinder part of its tail, but the fhell *f* was adorned with the like elegant apparatus and hair as I have reprefented in the tenth figure.

From hence, therefore, it is very evident in what manner this Snail, together with its fhell or ftony cover, is likewife by degrees increafed, augmented, and become larger in the uterus. This obfervation is indeed of fuch importance, that no body can defire any more worthy of notice. Whoever reads thefe things muft be obliged to confefs, that the power of the Almighty cannot be known, by clearer and more convincing proofs, in any part of his works, than in thofe minute animalcules, wherein that great Architect has inclofed and hidden fo many wonderful parts, and fhewn fuch exquifite art, that exceeds all human induftry; fo that one may employ his whole life in the diffection of the fmalleft of all animals. For this reafon I look upon the whole of my defcription to be like a delineation of the fun, defaced with coarfe materials; and therefore it is no wonder that the wife men of the heathens, when they had feen fome miracles concerning the nature of women, cried out, "O! Being of beings, have mercy on me."

I have not accurately inveftigated the remaining parts of the Snail, becaufe I only diffected two pretty large ones, and a fmaller one of this fpecies, and becaufe it happened only by chance, that I began this wonderful diffection, which deferves more than any other to be completely perfected; great numbers of thefe Snails may be found at any time. I fhall for the prefent briefly relate what more I faw of them.

I have obferved that this Snail has no teeth, but inftead thereof it has a probofcis, trunk, or little tongue, by the help of which it feems to take its food in as by fuction, as is the cafe in butterflies, and fome kind of beetles. This little tongue is fo elegantly formed, that it can fcarce be exactly defcribed, and as difficultly be reprefented in a figure; in the forepart it is of a bright or pellucid red colour, furrounded on each fide with many fmall parts, like the branchiæ or gills of fifh, or like a comb with a double row of teeth. Thefe little parts grow paler towards the hinder fide, and are of a horny fubftance, fuch as the little tongue has in its divifions.

The gullet is like a fmall filament. I have not diftinctly feen the ftomach, becaufe I had broken fome of the parts, but the part I took for the ftomach was like a membranous little inteftine.

The ovary is in every refpect like that of hens, only that its eggs are not fo large: I took thefe eggs in the beginning for a congeries or heap of chryftalline globules; but when I had dried them upon glafs they contracted, which is not a property of the chryftalline granules of this little animal; I found them alfo foft in handling and biting them. I have nothing to fay with certainty of the penis, though I faw fomething like one.

The liver confifts of diftinct vifible glandules, fomewhat like pears, and I confefs that the glandules of the liver never appeared plainer to me in any animal. As to the other parts of the abdomen, I have not yet either feen or examined them. The brain and nerves are conftructed in a very different manner from thofe of all other Snails that I have hitherto fearched into; neither have I inveftigated the eyes, fince, with refpect to thefe, this little animal agrees in fome meafure with cruftaceous animals, as Crabs and Lobfters: hence I thought I fhould have found fomething in it, like the eyes of the Hermit Crab, which I obferved to be like thofe of Bees. The cornea tunica of the eye was in this alfo divided into little fquares.

I have not been able yet to difcover how this egg comes out of the ovary into the uterus, for the bottom of the latter feems to be fhut up; but whether there be a tube in it there, as in Frogs and Tortoifes, I am hitherto ignorant; I am at as great a lofs to know what time the egg afterwards remains in the uterus, before the little creature is difclofed from thence as a perfect Snail. If we confider the remarkable fize of the fhell, we may reafonably conclude that the egg lies there a long time. Hence I fhould think that fuch fmall Snails and eggs may be found in the uterus at any time of the year. As to the Snails themfelves, I now know how to get a great number of them, nor will it be difficult to exhibit their fœtus.

Who can explain after what manner this egg is fecundated? or how life and motion are communicated to all its parts? fo that, like a clock, having been produced with all its wheels or limbs by its parent only, and having life and motion from the male fperm, it continues ftrong and vigorous, until its little chain be unwound: fo we may term the death of all thofe who have life and breath. Thefe things are known only to that moft fagacious Being, who has numbered and meafured the chryftalline globules, the hairs of the fhell, and all the parts of this little creature's body, nay of all animals, and who has given life and motion to every thing.

On the twelfth of March, in the next year after I began thefe obfervations on the viviparous Snail, I collected a great number of this kind, which I put into a large bafon full of rain water, and fed for a long time by the help

help of fome potters earth diffolved in the water. On the thirteenth of the fame month I opened one of thefe Snails, when I found nine living Snails in its uterus, each inclofed in its proper membrane; though the humour of the amnion was almoft confumed, which I looked upon as a certain fign, that their birth was near at hand. The larger of thefe fœtus's were placed foremoft in the uterus, and the lefs next in order. When I had afterwards cut them out of the uterus, and put them into frefh water, I found they lived to the eighteenth of March, moving themfelves, and fwimming like Snails more grown; nay, their manner of fwimming was much more beautiful; but as I then had other matters to attend, I poured them and the water out together, nor have I fince obferved any thing further in them. The largeft of thefe Snails were fomewhat lefs than thofe that are reprefented in Tab. IX. fig. IX. and the reft were ftill lefs in proportion.

On the twenty-firft of March I opened another Snail of that kind, in which I found forty-four larger, and fome very fmall fœtus's, each inclofed in its membrane, and placed in a regular order in the uterus: fome days after this I diffected three others, in one of which I reckoned fixty-five Snails, in the fecond fixty-feven, and in the laft feventy-four, the fmalleft of thefe young Snails were not bigger than the point of a little needle. When I afterwards viewed them in a dark place by candle light, I obferved that they fwiftly and very beautifully moved and twifted themfelves round in the humour or liquor of the amnion. But I found no eggs in the uterus of thefe laft; hence I learned that thefe fœtus's were arrived to their full perfection, and afterwards only increafed, that they might in fome months after be in a condition to be brought forth by degrees, and by this means give way to new eggs to be again received into the uterus at that time.

Wherefore at whatever time of the year, you open thefe Snails, you will always find them pregnant, either with eggs or living Snails, or with both together.

On the twenty third of March I obferved that fome of thefe Snails, which I kept in a larger veffel filled with water, had brought forth feveral young Snails of equal fize or bignefs. In fome days afterwards I again faw that other young ones were brought forth; fo that by this means, and fundry obfervations, I learned by very certain experiments, that thefe Snails continually bring forth throughout the whole year. When in the month of June I opened fome of thofe that had brought forth, I found many rudiments of eggs in them, and fome eggs of the fecond degree, which were already fo perfect, that the fœtus might be difcovered in them; nay further, fome eggs were ftill more perfect; they lay in the uterus, and the young of them were to be produced foon.

In the month of June almoft all my Snails died, becaufe I neglected to give them frefh water, and therefore in order to preferve them for fome time, I put them into fpirit of wine among others which had perifhed fome weeks before. I afterwards fhewed above fixty young Snails, in the uterus of one of thefe to Dr. Huygens, who, on his return to Paris, honoured me with a vifit; at which fight he was greatly aftonifhed, and highly admired the ftupendous and impenetrable fecrets of nature.

On the twenty-fourth of July I weighed one of thefe viviparous living Snails that was frefh taken, and it weighed five drachms; in its uterus I found many eggs, in moft of which was to be feen a moveable whitifh fpot or point, but in the reft of them Snails of a larger fize were obferved, fo that all the larger Snails were then already hatched. Then I began to clear the fhell of this Snail of its dirty cruft, and I found the periofteum underneath unhurt. Its colour was then yellow mixed with green, and it was variegated with light red furrows and ridges; when the periofteum was pulled off, the fhell appeared white, and the ribs or ridges appeared of a purplifh red. I have delineated a fhell of this kind in its natural bignefs, in Tab. IX. fig. XIII, where the ftructure, windings, fibres, and aperture of the pillar may be clearly and diftinctly feen in it.

Of that fpecies of the Sea Snail, called by the Hollanders Aliekruyk.

Though many fpecies of fhell-fifh, of the Snail kind, are found in Holland, I do not know that any of them are eat, except only this fea kind, which is of the genus of the Turbo, and is called Aliekruyk; nor do we eat them at all times of the year, but only between Eafter and Pentecoft, and a few days after. At this feafon, hogfheads of thefe Snails are carried into cities, and, being firft boiled with water and falt, are fold out by meafure. Seafaring perfons in particular, and thofe who defire to provoke thirft by falt meat, eat thefe Snails, taking them out of the fhell with a needle or little pin, and then they drink a large draught. For my part I do not like the tafte of them; nay, they feem to me to affect the palate with too much faltnefs, and a kind of rank flavour. The liver is the moft favoury of all their parts; in the reft they eat hard and tough, and are therefore ufed, as I have faid, rather for whetting the thirft, than as food. Their entrails alfo are fo full of dirt and fand, that they crafh between the teeth.

These ſhell-fiſh are found very numerous on the ſhelves or ſand banks near the ſea, where the muſcles are alſo found, and among the latter they are frequently ſold; but they have alſo peculiar and proper places, in the ſea, where they ſtick together in large heaps. I have ſometimes taken them from the piles of timber, on which they are often fixed in the ſea, and ſometimes I have pulled them from large willow ſtumps, which were formerly laid on the ſhore, to break the violence of the waves; between theſe ſtumps, and among ſtones, are ſometimes found many other rare water inſects, as the Pulmo Marinus, or Sea Lungs, the Urtica Marina, or Sea Nettle, a ſpecies of the Echinus, the Stella, or Star-fiſh, Tubuli, or Sea Worms, Aſelli Marini, Sea Wood-lice, and others. The maritime coaſt of Holland is the only place I know wherein one can make theſe uſeful obſervations, for all other coaſts in general are ſmooth and plain, or covered even with ſand.

That this ſhell fiſh may be better known, I ſhall firſt deſcribe its external, and then its internal parts. Among the external parts I reckon the ſhell, which is the ſtony skin of this Snail, as well as of all other inſects that inhabit ſhells, it is on the outſide inveſted with a perioſteum, which appears very beautiful in young ones, becauſe no part of the ſhell has been in them worn out or rubbed off. Underneath, where this Snail, Tab. IX. fig. XIV. *a*, creeps out of the mouth, the door or entrance of its ſhell, the latter is a little globular *b*, but it loſes this figure by degrees, after it is rolled five times, 1, 2, 3, 4, 5, and is terminated in a ſharp point. The external ſurface of this ſhell is rough and unequal, ſince from its mouth or entrance to its acute end, it is folded and curled with thirty-one little ribs or furrows, which appear like ſo many threads above the ſurface *c*. I have not met with this exact appearance in all of them, as it ſeems in many to be worn out and obliterated with age; for the older ones have poliſhed ſhells, and are divided, fig. XV. *d*, only by ſome rings or wreaths of divers forms and colours; unleſs theſe ſhells may probably belong rather to another particular ſpecies, which I think is moſt probable. As to the colour of the ſhells, it is a light red in the former ſpecies, but in the other it is mixed with green and aſh-gray, and ſometimes red, purple, blue, or whitiſh. The internal ſurface of the ſhell is all equal and ſmooth, it is of a dark brown in both ſpecies, ſomewhat inclinable to a bluiſh purple.

The ſhells of theſe Snails are frequently eaten through, by ſome of the largeſt Sea Worms *, as may be ſeen particularly in the upper or pointed extremity, for it is frequently found gnawed there in conſiderable holes, in ſuch a manner, that the whole figure of the ſhell is obliterated in that part; nay, I found from experience, that thoſe worms ſometimes perforate into the inward texture of the ſhell, and there form various crooked and oblong hollows, Tab. IX. fig. XV. *e*, which ſometimes penetrate into the cavity itſelf, ſo that the Snail is obliged to draw up the hinder parts of its body.

I have found ſeven ſuch Worms in one ſhell, the Snail whereof was ſtill living and unhurt. I here exhibit one of theſe Worms, fig. XVI. *a*, if this Worm be viewed with a microſcope, it is found to conſiſt of many annular inciſions, which are adorned, fig. XVII. *c c*, with ſmall hairs on each ſide; in the middle are ſeen two veins of a bloody colour, which extend their little branches on either ſide towards the interſections of the body. In the fore part of its head *a* are alſo ſome hairs, which are placed there like antennæ or horns: the like *b* are ſeen alſo at the tail. All theſe Worms had a very thin skin; they were of a tender conſtitution, and moved but very little. Whether this might have proceeded from my hurting them, by ſtriking them with a hammer, or was natural to them, I cannot ſay. In the foulneſs which adheres to Oyſters, I ſaw a ſpecies of larger worms, which were not in figure very unlike this ſmaller kind, and, like the Glow-worm, ſhined in the dark.

All theſe ſhell fiſh ſeem to be ſubject to this Worm as a diſeaſe, ſince few of them are met with, whoſe ſhells are entire and ſound at the end of their convolutions or windings; for the ſhells are always inveſted there with a dirty or filthy aſh coloured ſubſtance, wherewith they are more or leſs infected, and in which theſe worms ſeem by degrees to fix themſelves, ſo that at length they ſeize on the ſkin of the ſhell fiſh, as their proper habitation and food, though the Snail ſtill continues to live in it. This ſhell has very hard and ſolid joints, as appears in its ſpiral pillar, which is likewiſe very thick; hence it is that the Snail may be eaſily diſengaged from it, ſince the ſhell flies in pieces like a flint, if it be ſtruck ever ſo lightly with a hammer.

The body of the Snail, which creeps out of this ſhell, but is by its muſcles very ſtrongly annexed to the pillar of it; the head and mouth, Tab. IX. fig. XVIII. *a*, are nearly like the Snails, and ſo are the horns *b b*, and eyes *c c*. The colouring of the ſkin only differs, for it is variegated with black furrows and ſpots on a white ground: in regard however to the colour of the two ſpecies, there is ſome difference to be obſerved. Behind, at the verge of the body *d d*, is the Snail's operculum or cover *e*, which it ſuddenly draws in at pleaſure, and by this means ſhuts up its ſhell, when it meets with any thing unuſual: the creature provides for its ſafety in the ſame manner, when any thing is ſuddenly preſented to its eyes; ſo that I may venture to affirm from hence, that this is the only ſpecies of Snails that I know, wherein any

* This is a common accident to ſhell fiſh: not only worms gnaw the ſhells, but the large ſhell fiſh of ſome kinds have a kind of bony engine, with which they pierce the ſhells, to get at the creature for their food. When it was doubted, whether foſſil ſhells were real, or exuviæ of animals, or repreſentations of them, from the ſportings of nature, ſhells taken out of the earth thus pierced by Pholades, were produced, and the objections ceaſed.

manifeft figns of fight appear; though in the mean time the eyes of this fnail do not, in refpect to the parts which are common to the eyes of all Snails, differ any thing from thofe of others. On the infide, at the edge of the fhell, is feen the verge, which furrounds the whole body, and is pervious to no air: this I have remarked alfo in other fpecies of Snails. On the right fide of it are two other apertures, one of which ferves to evacuate the fœces, through the other the genitals are extended. And thefe are all the outward parts of this little creature. Moreover, this Snail is of a very ftrong conftitution, for it can live ten or twelve days in the open air out of the water. I have alfo obferved, when I was fometimes in the month of September in the town of Petten, where thefe Snails are found in great plenty, near the fea piles or fea marks; that they ftuck quietly on the dry land, after the tide was out, and on its flowing, were again buried under the water; fo that they may, on this account, be confidered as real amphibious creatures. The fhell *f* wherein I exhibit this Snail, belongs to the fecond fpecies, and fhews its fafciæ or wreaths nearly worn out. The operculum or cover confifts of a flexible horny fubftance, fig. XIX. *g*, which is compofed of filaments applied to each other, and rolled like the fpiral convolutions of fome fhells.

I fhall give but a brief defcription of the internal parts, both becaufe I employed only half a day in examining them, and becaufe they do not differ much from the entrails of other Snails. To begin at the mouth, we muft obferve, that all the parts of the jaws and palate are in this Snail of a bloody or purple colour. In the middle of the mouth is feen the tongue, Tab. IX. fig. XX. *h*, included in a fingular kind of cavity, the whole of which it feems may be extended together out of the body; in the refpects of colour and ftructure it does not differ much from the tongue, which I have delineated and defcribed in the Sepia or Cuttle-fifh; but it differs very much from the latter in this, that it is almoft two inches long, and at the fame time beautifully convoluted or twifted *i* into fpiral bendings, like a ferpent clofely rolled together, and is thus placed on the infide in the body, fo that it paffes with the gullet under the brain. The brain is fituated behind the feveral parts of the mouth and palate, over the tongue and gullet, and ferves thofe parts before defcribed as a kind of pully, through which they are tranfmitted. The part of the tongue which is in the body is cartilaginous, and fo artfully and beautifully formed, that I could not delineate it fully in ten days; for which reafon I exhibit it only in its natural fize. In the hinder extremity the tongue is of a fofter texture, and there includes a white matter in its cavity, which, when expofed to the air, dries away and vanifhes, contrary to what happens in the upper part. The ufe of this tongue will be manifeft to any perfon who inveftigates it with more experiments.

On either fide, near the tongue, are feen the falival ducts, which arife from whitifh and branchy glandules, and reach to the jaws behind, under the proper parts of the mouth and palate; and immediately under the gullet, two glandulous white little parts likewife come in view, the ufe of which I do not know: under thefe, on each fide, are feen nerves iffuing out of the brain, of which the optic nerves are the moft confiderable. The eyes, for the ufe of which thefe are appropriated, have three fuch humours as I have before defcribed at large in other Snails; the only difference is, that where the eye adheres to the skin, it is furrounded with a kind of white narrow circle, which I have not indeed obferved in other Snails.

The ftomach likewife is provided in the fame manner, as it is in the garden Snail, and when it has decreafed into a fmall inteftine, it afterwards proceeds according to the convolutions of the fhell, and by its fpiral and pyramidal windings, furrounds the liver, which is of a dusky colour, fomewhat approaching to that of musk. The liver confifts of pretty large vifible glandules, which feem to communicate one with another, in form of a fhrub; as foon as this inteftine has paffed through the liver, and the whole circuit of the fhell's convolutions, it forms the inteftinum rectum, or ftraight gut, wherein I have obferved the excrements divided into quadrangular globules.

The heart with its auricle is fituated toward the left fide. All the blood veffels are of a whitifh colour, and refemble a Spider's threads: this is a very great beauty in the inteftines of this little creature. I could not fee the facculus calcarius, or the calcarious bag, nor the chain-like little part. Nay, feveral of the genital parts could fcarcely be diftinguifhed in this fubject, for I began this diffection and examination in the firft fpecies of thefe Snails, at the end of the year, that is in September. But the purple-bearing oblong little tube, together with fome of the other entrails, were diftinctly feen to be of a very elegant ftructure; all which I muft pafs over now, and fhall refume this diffection at fome other convenient time.

Of the fmall water Turbo.

Some fmall Turbines are commonly to be met with, Tab. X. fig. I. *a*, in the places where the wonderful Snail, laft defcribed, is found. Thefe feem to agree entirely in ftructure and conftitution with the viviparous Snail, nor do they obvioufly differ from it, only that their fhells are fomewhat longer. I have not yet found them of fo large a fize as I could wifh, and as I have not them now alive, I cannot exhibit the figure of this creature, I therefore hope that the benevolent reader will be fatisfied with the figure of its fhell only.

Of

Of the umbilicated marble Snail.

This little Snail, which is variegated in the manner of marble, inhabits the frefh-water rivers of Holland, and therein adheres to fmall ftones: I have found it in the Vecht, beyond Amfterdam. It is frequently found about pieces of brick-bats and tiles, or pot-fherds, broken pieces whereof have been thrown into the water. In the fore part, where the fhell gathers into a fpiral form, fig. II. *a*, it refembles an umbilicus or navel; then it bends or rolls round in an oval winding, and becomes more expanded *b*. It is of a green yellow colour, variegated with a reticulated black ground like marble. The Snail that lives within is very tender, and as it died before I had brought it home and opened it, I cannot fay much concerning it, nor exhibit the figure of its body. I faw that it had two oblong and fharp horns, and two black eyes. The ftructure of its tongue is almoft the fame with that of the wonderful Snail. It had pretty ftrong little inteftines. Its body, which was contained within the extreme fpiral part of its fhell, was of an obtufe figure; becaufe, probably, this fhell was very thick, firm, and folid. To the lower part of the body adhered a calcarious operculum or cover, which had a kind of fwelling or peculiar production where the mufcles were inferted into it, fo that it refembles the fhoulder-blade in the human fkeleton. On the outfide it was twifted fpirally like the fhell itfelf. On the inner part, where this Snail creeps out of its fhell, the opening or entrance, which is formed like a crefcent, only was open, and over-againft it I obferved a certain greenifh fpot, which refembled in fubftance the fhell of mother-of-pearl, and was likewife of the figure of a crefcent. To this fpot the operculum or cover applies itfelf, when the Snail creeps out of its fhell.

The flattened Snail.

Since many fpecies of Snails are found in the rivers of our part of Holland, I fhall briefly defcribe only one kind of the water race, which is to be found there very common, both in falt and frefh water, as alfo in pafture grounds and near the high-ways. Its body is gray or blackifh. On or at the fore part of the head are obferved two lips, Tab. X. fig. III. *a a*, joined together, under which is the Snail's mouth, formed in the fame manner as it is in the common water Snail. Under the mouth there is to be obferved a part of the body, which I call the verge or foot *b b*, becaufe it ferves it to creep with. The Snail frequently expands this verge in fuch a manner as to cover the lower part of its lips and mouth therewith. A little higher in the head are two black eyes *c c*, fituated at the bafis *d d* of the horns. Thefe horns are very fharp in the fore part, but broader behind, and the Snail can contract them in fome degree, but it cannot abfolutely draw them back into the body.

When its body *e* is pufhed forward out of the fhell, it is confiderably long and flender. Near the fhell is obferved a part of the verge, which the creature can raife out of the water when it fwims; fo that by means thereof, it may draw the air into its body; the verge therefore has for this purpofe a fufficiently large aperture, Tab. X. fig. III. *f*, in which is feen the openings *g* defigned for the organs of generation.

Its fhell or hard fkin is twifted or rolled about in a wonderful manner, and on the left fide it is fmooth or flat *h h*. It is invefted with a diftinctly vifible periofteum, and is divided by very fmall incifions, ribs and furrows. But if this fhell was fo foft as that it could be rolled out, an oblong tube might be made of it. On the right fide it is concave or diverging as it were from itfelf, but on the infide it is rolled into itfelf, fig. IV. *a*, and therefore leaves a fmall aperture in the middle, which I call the cavity of the pillar.

This Snail is a kind of intermediate fpecies between the common water and viviparous Snail, as will appear from its diffection now to be exhibited. It is very difficult to diffect it, for it cannot be killed without hurting it, and it will not admit of being diffected alive. However, I do not doubt but I may be able to furmount this difficulty, by the invention of fome proper apparatus for that purpofe, which I the more ardently wifh for, becaufe as foon as one begins to break open the fhell of this Snail, it immediately difcharges a purple fluid or humour, which diffufes itfelf throughout the infide; even through the vifcera. If you kill it in fpirit of wine, it likewife expels this purple fluid out of its body; but when it dies naturally in a little water, it fhews no purple, becaufe the colour then probably vanifhes by the changing the difpofition of the parts. When this Snail is drowned in milk, in which however it will live for fome time, it is notwithftanding found that the purple humour does not remain in the veffels appropriated to it by nature: and though I faw the heart beating, yet I never found this purple liquid in it or its auricle. Hence I am inclined to think, that this liquor is contained in a kind of facculus or bag, which I have feen in other Snails, but could not hitherto difcover in this.

The fhell being gradually and carefully broken off from the body, the diffection fhould commence from the aperture of the verge. It will then appear, that this Snail agrees greatly with the wonderful fpecies; for the verge is likewife here provided with a fimilar fmall margin beautifully folded, and made in the fame manner as in the Snail before-mentioned; for in its texture is likewfe found a very great number of fuch chryftalline globules, which crafh and make a noife under the inftruments. On the other, that is on the right fide of the verge, is alfo obferved a congeries of fuch Worms, as I have in like manner

manner observed in the viviparous Snail; and if these Worms be dissected, a great many smaller ones, with thick little heads issue from them, which will likewise swim with very great velocity, and they also are stronger in their life and motion, than those which I have described in the account of the viviparous Snail.

These Worms likewise creep with very great swiftness; first stretching their head forward, and then, with great force, drawing the rest of the body after it. Their greatest strength is in their mouth, which may probably have a kind of feet, as I have seen in other little creatures, and shall hereafter describe and exhibit in figures. These Worms are much smaller in this than in the wonderful Snail. When I was certain of this fact of the Worms, from observation, I kept some thousands of them in the water, wherein I kept these Snails enclosed in a large glass vessel, and I saw that they moved swiftly. The little part of this Snail which contains these Worms in the upper part of its membrane, is on the inside of a bright yellow colour; and, in my opinion, may probably be accounted analogous to the purple-bearing bag in other creatures of this kind; but this I shall not affirm certainly.

This Snail agrees with the common water Snails with respect to the external structure of the mouth and teeth. It wants an operculum or cover, but as to most of the viscera it is likewise like them. Its stomach is formed in the same manner as that of the Hen. The brain is situated alike, though there is some difference in the nerves. The heart is placed in the left side of the body. But there is one peculiar thing in this, which is, that the liver consisting of glandules, is not protended to the extreme cavity of the shell: I have found there a small part which was filled or crammed as it were with myriads of the thick-headed little Worms before described. The chain-like little part follows next, behind which is placed another glandulous purple-coloured small part, and after this again is seen another yellowish little part near the uterus, which is of the like structure with that in the water Snail, and opens with three tubes into the hinder part of the neck. The penis is formed in the same manner as in the common water Snail, nor has it any thing peculiar in it, only that where it is extended out of the body, three small folded parts are seen, the middle whereof is very beautiful, and is, in some measure like a mushroom, supported by a small foot, and divided on one side.

The small flattened Snail.

This Snail is in most respects like the former, nor does it differ from it, except that its shell is on each side almost smooth, and is concave, and adorned with a small kind of margin, Tab. X. fig. v. *a*, by the addition of which it happens that the furrows or little ribs in the surface of the shell are bent in a different manner. It is seldom found larger than it is here represented. There is also some slight difference in the external part of the body. The horns are flesh-coloured, though the body itself is blackish. The shell of this Snail put in the sun is almost all transparent, but particularly in its internal windings, which are on every side stained with purple. The punctum saliens, or beating heart, is observed to be deeply tinctured with the like colour. But if the body of this Snail, after it has crept out of the skin or shell, be pierced with a small needle, and the needle afterwards extracted, it draws back its body very deep into the shell; and then it is observed, that a juice of a purple colour insensibly distils out of the wound. This I take to be a certain sign that this little creature has purple blood. Whether this same thing holds in the foregoing Snail, is yet to be discovered as also in a smaller one; the shell of which is likewise probably so thin as to be transparent. This and the former Snail are found in the ditches in Holland, as well as near the highways and in pasture grounds.

Of fresh-water Muscles, found in the rivers in Holland.

IN the river Vecht above Amsterdam, and in other rivers, is frequently found a species of Muscles, which are indeed buried in the clay and mud next to the banks, but they lie free and disengaged, and stretch out their sharp-pointed part. When the bottoms of the Vecht or neighbouring ditches are cleaned, these muscles are found in great numbers. I discovered three species of them; a larger sort with thin and broad shells; a smaller more oblong, and with thicker shells; and a very large kind, which is of a somewhat different texture.

I only examined the middle species of these, that is, those which are most common. These do not open themselves much, they only make the two wings or lips of their bodies to swell a little out of the shell, and by this means they can fill themselves with the river water. Besides, they emit out of the shell some small ruddy apiculi, or small points, with sharp extremities; and, as those are on the hinder part covered with a blackish substance, they resemble so many sharp and black little spines, made like the papillæ that are observed on the surface of a Cow's tongue.

I had intended to complete the whole anatomy of these Muscles; but when I opened two of them, all the parts that I found in them were so strange, and so much unknown to me, that I desisted from my purpose for that time. For, as I had never before accurately dissected any species of Muscles, I saw that it would have taken up a very long time to have finished this business, and I was then deeply engaged in other matters. I therefore reserve this work for

for a more proper opportunity. But I ſhall now briefly relate what appeared at firſt ſight to me on the inner and outſide of this Muſcle, and in its ſhell, and ſhall, in particular, explain ſome things concerning the inſertion of its muſcles; whereby the hiſtory of what I have before ſaid of the Muſcles being inſerted in the ſhells of the Snails, will be conſiderably illuſtrated.

When the ſhell of this little Muſcle is carefully broke in little pieces with a forceps, and ſeparated in the part where the Muſcles are inſerted, then offers itſelf to view in the creature, its lips, and with this the verge; theſe wind about the whole body, and cover it as it were with two wings or lips. One of theſe is obſerved to be, Tab. X. fig. VI. *a a*, bent back to the ſide of the body. On the lower ſide of it, and likewiſe on the other ſide of the body, are ſeen papillæ as before mentioned *b b*, tinged with a black colour, which may eaſily be wiped off with a bruſh. The papillæ ſeem to me to be the extremities of ſo many tubes or trunks, whereby the Muſcle draws into its body, ſmall particles of mud and ſlime, for the gullet ſeems to communicate with them. On each ſide of the body are four branchiæ or gills, each conſiſting of three membranes, the middle whereof is formed like a bull-ruſh mat, and is compoſed of longitudinal and tranſverſe filaments, and may be ſeen through both the external membranes. All theſe filaments ſeem to me to be tubes, through which the blood moves as it does in fiſh. The largeſt veſſels are ſituated in the lower part of the muſcle; and from thence ariſe, I think, thoſe tubes, which, whoever purſues them ſo far, will find pretty ſtrongly connected with the papillæ that draw in the food. On each ſide, the Muſcle Tab. X. fig. VI. *cccc* has four ſuch larger branchiæ or gills, and four other ſmaller ones, *d d d d*, placed towards the hinder part.

The body itſelf conſiſts of two parts, a hard *e* and ſoft *f*. Theſe I take to be the thorax and abdomen. The harder part is made up of a congeries of many muſcles, which run from one ſide of the body to the other, with ſtrata or layers of long fibres, and being then carried over the ſoft part towards the branchiæ or gills, and wings or lips, they afterwards give various muſcles underneath to the belly. The thorax riſes into a point, and is of a colour ſomewhat approaching to yellow. When opened it exhibits many muſcular fibres running tranſverſely from one ſide to the other, from which the thorax obtains its hardneſs and ſtrength. Under this is placed the brain covered, with a bright-yellow membrane; but the ſpinal marrow and nerves are white, and they are divided into branches which are detached in great numbers to the muſcles.

I find four different parts in the abdomen, a liver, fat, an aſhy-gray ſubſtance, and ſeveral membranous and muſcular expanſions. The part which I take to be the liver, is very large; it conſiſts of a congeries of ſmall oblong glandules, which are placed near the hepatic veſſels, and reſemble ſo many uvulæ reſting on their little ſupports. Its colour is a blueiſh red, and where the veſſel is thickeſt, a glutinous matter is contained in it. There is a great quantity of what I call fat in the abdomen; it is divided into ſmall glandulous little knots, and is of a bright white colour, ſo that one would take them for little eggs, only there is ſo great a quantity here, that it reaches even to the ſpinal marrow. Many membranous and muſcular expanſions are likewiſe ſeen in the belly, but whether they are interwoven with veſſels and nerves, or with muſcular fibres, I cannot exactly determine. To conclude, there is likewiſe a great quantity of aſh-coloured matter, diſtributed among the fat: we find the ſame ſubſtance depoſited round the larger veſſels of the branchiæ or gills, and in many other places.

I could not hitherto diſcover either a heart or a ſtomach in this creature, but ſhall reſerve both for further inquiries. The principal muſcles that ariſe from the back are here very ſtrong, and divided into many tendinous fibres, and are firmly inſerted in the ſkin or ſtony ſhell of the creature, ſo that by this means various holes and cavities are obſerved to be formed in the ſhell, becauſe ſome of the tendons are fixed in it deeper than in others. Out of the back ariſes, among others, a very beautiful ſmall muſcle, which paſſes through the ſhelly part that joins the two valves of the ſhell together, as through a pully, and is afterwards inſerted in the ſharp-pointed extremity of the ſhell: but the muſcles are not ſo ſtrong about the acute extremity as elſewhere. The ſame are likewiſe very ſhort, which is the reaſon that this Muſcle can open the valves of its ſhell but a little way; ſo that if you attempt to ſtretch them further, even with the leaſt force, they immediately break.

On the inſide of the ſhell are obſerved five particular parts, in which the muſcles of this creature are inſerted, that is in the fore part of the acute extremity, where the inſertion is indeed broad and formed into a circle, Tab. X. fig. VII. *a*, but not very ſtrong. The Muſcle is very ſtrong at the thick end of the ſhell, becauſe the muſcles are there very firmly united with the ſtony bone: but one may there ſee four little apertures *b* ſunk in the ſhell, wherein the tendons of the muſcles are united with the ſhell, or rather change into a ſhelly ſubſtance. The muſcles of the lips are inſerted, but not ſtrongly, almoſt in the whole circumference of the ſhell next to its extremity *ccc*. We obſerve that the ſpiral worm *d* of this ſhell ſwells ſomewhat beyond its arched cavity. There are alſo two eminences *ee*, by the help of which both valves of the Muſcle are very ſtrongly joined together as by ginglymus; which, together with the parts wherein the muſcles are inſerted, make a very beautiful appearance in ſome other ſpecies of Muſcles, and are wonderful in the larger ſhell-fiſh of this kind. This ſhell is on the inſide like that of mother-of-pearl. On the outfide it has various convoltions or little ribs, formed like crefcents, and is furrounded on every fide with a ftrong yellow-green membrane or periofteum.

I have nothing more to fay of this and the other creatures, as I only flightly made thefe particular experiments, that I might, as far as time would permit, illuftrate the hiftory of the covered Snail by the defcription of fome other kinds. I have examined into thefe things, that the reader, myfelf, and all mankind may learn to know God by his wonderful works, and adore and love him as the fupreme Deity and the great Creator of nature. Doing this, we fafely purfue the fteps of Chrift, in and by whom every thing we do muft be acceptable to God: but if we do not follow or imitate him, we are like thofe carelefs fervants, who buried in the earth the talents committed to them, which God grant may not be our cafe; and may all perfons, according to their refpective abilities, extol and praife him; for which end I have communicated thefe obfervations as my mite, and wifh they may anfwer the intended purpofe.

The method of cutting various images and figures in fhells.

BEFORE I conclude the hiftory of fhell-fifh, I fhall firft fubjoin a method, whereby fhells may be engraved and adorned with little pictures and figures, which is indeed a bufinefs of exquifite art. Take yellow wax, and mix a little Venice turpentine with it, to make it more clammy, then add as much lamp-black with it as will make it very black. With this wax melted in a fpoon, we may make any figures we think proper, on the furface of the fhell, to be carved; then we cover thofe parts that are left uncovered with wax, with aqua fortis, which may be conveniently done by the help of a skewer, with a fmall piece of linen wrapt round it. If this be continued for a fhort time, all the parts of the fhell that are free from the wax will be eaten by the aqua-fortis, and in thofe places covered with wax will be left an higher furface. And by this means the fhell may be adorned with various figures, and apartments or divifions, which appear to be externally made thereon. But if after the wax is fcraped or taken off by melting it, any corners or uneven parts fhould chance to remain, they muft be planed and perfected with the inftruments wherewith figures are engraved. Thus three, four, or five eminent figures may be executed one over another, according to the thicknefs of the fhell, and the places which we would have elevated, are firft covered with melted wax. But the place which the aqua fortis corrodes with its acrimony, ought to be wafhed with common rain water. Other corroding liquors are not fo proper for this purpofe as aqua fortis, becaufe they leave after them a fandy fubftance like chalk, which produces a roughnefs that renders the appearance lefs agreeable.

The end of the hiftory of SHELL-FISH.

A letter from John Swammerdam to the moft illuftrious Mr. Thevenot, on the anatomy of the Cancellus or Bernard L'Hermite.

ILLUSTRIOUS SIR,

WHEN I had the honour of your company for fome days in Yffi-ftreet, it often happened that fome miracles of nature excited us to admire the great Creator, who is aftonifhing in all his works. We have alfo debated on the fame fubject often, when you refided in Holland, and I have fhewed you various uncommon experiments on bees and other fpecies of infects. But fince the fecrets of nature have, by the many inftruments and contrivances which I have invented, become clearer and more known to me; and fince I can in one day inveftigate what I have before fpent a whole week on; I can therefore now add a great deal to the difcoveries I formerly made. This you will be convinced of from the defcription of the internal and external parts of the Hermit Crab, which I firft obferved fome years ago at Scheveling. For, as Dr. John Oort, governor in Nyenrode, fent me a large veffel of thefe creatures, which, the better to preferve them for fome time, he had taken care to throw into fpirit of wine immediately after they were caught: I cannot help giving you a full defcription of what I obferved in them, and what obligations I am under both to my old friend, the governor of Nyenrode, who is greatly delighted with the works of God, and to you, illuftrious fir, who keep me continually employed in thefe matters, and engage and perfuade me to fearch into them. All mankind will admire the ftupendous examples of the immenfe greatnefs of the wonderful works of God, which that fupreme architect exhibits to our contemplation in the variety of the things which he has created, that we may acknowledge his wifdom and infinite power in the works of nature, and be induced to love him moft ardently, and above all things.

The

The fiſhermen who get their living in the ſea of Scheveling, take there ſeveral ſtrange creatures, as well in common nets as in drag nets, which they either throw again into the ſea, or leave on the ſhore, ſince they can get no profit by them. This is the reaſon that it is not yet known, how many and what wonderful creatures there are, to which the eternal power of God has aſſigned the ſalt waters as their habitation. I wiſh many more men had ſuch an ardent love for the ſciences, as you and the governor of Nyenrode, our friend, for thus the knowledge of natural ſcience, and the hidden cauſes in phyſicks would, by degrees, become known; and the incitements to our duty, by which we are ordered to love our Creator with all our heart, would be doubled. I am greatly obliged to you, becauſe when you were in Holland, you ordered many ſtrange creatures to be brought me from Egmont-ſtreet, which we afterwards examined with our common and dear friend Dr. Stenon. But I fear my long preface makes me troubleſome to you, by delaying the expoſition of what I promiſed, and the gratification of your eager curioſity. I ſhall therefore now relate to you in order, what I have obſerved in the ſpace of two days in the Hermits tranſmitted to me, and what ſtupendous things I ſaw in them.

The external parts of the Cancellus or Hermit.

IN the open veſſel wherein my Cancelli or Hermits were incloſed, I ſaw ſome of them had broken out of their ſhells, and that others ſtill lay in them. The ſhells of the largeſt were as big as a cheſnut, but thoſe of the ſmalleſt were not bigger than a large pea. The creatures themſelves who inhabit the inſide were large or ſmall, in proportion to the ſize of their ſhells. But all theſe ſhells were of the ſame figure, form, and habit, only that there was ſome ſmall, and, as it is called, accidental difference, in reſpect to the colour and lines. Some of the Hermits which ſtill lay in their ſhells, were diſengaged from the ſhell, ſo that they were affixed, by the ſtrength of their tail only, in the laſt ſpiral windings of it; but in others I ſaw very diſtinctly that in the middle of their body they were joined in the ſame manner to the ſhell itſelf *, and this is a property common to Muſcles and Snails. Hence, it appeared to me moſt certain, that the ſhell was as much the true skin of the Hermit as it is of the Snail.

Hence it ſeems matter of wonder that the learned Rondeletius ſhould write of the Cancellus or Hermit in this manner: "Bernard "L'Hermite ſe loge toujours dans les coquilles "d'autrui, et qui'l n'en a point de propres;" that is, "the Hermit always inhabits the ſhells "of other creatures, nor has it any of its "own." I obſerve in the covered Snail, that by the help of its muſcles it is not only affixed to the ſhell, but even the tendons of thoſe Muſcles increaſed with the ſhell, and are actually transformed into it, in the ſame manner as the tendons of the feet of Cocks and Peacocks are inſenſibly oſſified through age. The ſame thing is alſo obſerved in the Hermit, for the tendons of its muſcles, firmly adhering to the ſpiral pillar of the ſhell, where the pillar forms its ſecond ſpiral winding, are obſerved to be all joined to that rocky ſubſtance. But as the tendons do not occupy a great ſpace with their inſertions; therefore the body of the dead Hermit quits them: and this was probably the reaſon that the great Rondeletius, following the doctrine of Ariſtotle, has not obſerved this matter. As all theſe ſhells have one and the ſame figure and ſtructure, it is manifeſt even from hence that they are proper to theſe creatures only, and are increaſed and augmented with them, as is the caſe in Snails and all other creatures that inhabit ſhells. I am therefore certain, that all Hermits which belong to the ſame ſpecies have likewiſe ſimilar ſhells; for I am taught by experience, that there are many ſpecies of Hermits that are not only very different from one another, but alſo live in different kinds of ſhells; this I have ſeen in my father's collection, and in many other muſeums.

The ſhell of the Hermit is moreover ſurrounded with a very thin perioſteum, and hence ariſes a new argument, which confirms, that the ſhell is the ſkin of this creature, which, with its perioſteum, covers it on the outſide. So that therefore the Hermits, as well as Beetles and cruſtaceous creatures, have their bones placed on the outſide round their fleſh, though there is ſtill ſome difference. This perioſteum is very thin, nor can it be better or more perfectly ſeparated, than by ſteeping the ſhell ſome days in lye, and rubbing it lightly with aqua fortis, for thus it parts from the ſhell. By this method the perioſteum may likewiſe be very eaſily ſeparated in ſome other ſhells. But it is ſo thick and remarkable in ſome kinds, that there is no need of this experiment. In other ſhells, again, which are rolled over rough ſtones, or that have been drawn through rocky and ſandy places with their inhabitants, this perioſteum is wholly worn off, and cannot therefore be then diſcovered in them.

Some of theſe ſhells were very ſmooth and beautifully coloured, Tab. XI. fig. 1. *a*, and glittered like a looking-glaſs. A ſpecies of the Fucus Marinus, riſing with ſmall points, covered the largeſt of them in ſuch a manner, that the whole figure of ſome were obſcured and hid,

* The ſolution of theſe problems remains for future obſervations. This author aſſerts, that the body of the Hermit grows to the ſhell; others affirm, that the creatures will at any time crawl out of the ſhell, on ſmoaking them with ſulphur: if ſo, the ſhell is no part of the creature.

nor could the ſpiral windings of ſome of them be ſeen *b*. Moreover ſome holes appeared behind the points, and alſo ſome very ſingular little grains of ſand, ſome of which were likewiſe covered with the Fucus. Other holes were obſerved likewiſe full of ſofter purple coloured eminences. In ſome of the ſhells a ſoft ſea mud was found, in others a very hard one, the figure whereof was likewiſe ſpoiled by winding round the creatures. I likewiſe ſaw that a ſubſtance adhered to the internal ſurface of one ſhell in ſuch a manner, that there was no void ſpace either in the entrance or mouth in the fore part, or a little higher in the ſhell; only where the tendons of the muſcles were ſeparated from the ſubſtance of the ſhell. I obſerved further, that Worms had pierced the ſhells in ſome places, and how ſome of them had been broken and again joined together. Theſe ſhells are uſually moſt beautiful when the Hermits are ſmalleſt in them, for they are not then covered. In ſome other young ones of theſe, the perioſteum appears of a very remarkable figure and beauty, where the ſhells are not yet covered with the accreted matter; as I have obſerved in ſome ſmaller water Snails, in which the whole perioſteum was very delicately adorned with briſtly hairs. Let what has been hitherto ſaid of the ſkin of theſe creatures ſuffice. I ſhall now explain the other parts of the Hermit, and that they may be the more eaſily underſtood, I ſhall divide the creature into four parts, the head, thorax, abdomen and tail, and ſhall afterwards deſcribe every thing remarkable in each.

In the upper part of the head are ſeen two eyes, Tab. XI. fig. I. *c*, and on one ſide of the latter, two horns or antennæ *d d*. Underneath appear ſome articulated briſtly hairs, and alſo a mouth and teeth. The eyes are oblong, ſomewhat red, and in their aperture of a dark green colour: they are articulated on both ſides with the head, by the aſſiſtance of a certain dentated ring, which conſiſts of a like ſubſtance with the ſhell that ſurrounds the thorax and feet, and the other part of the eye is again articulated with the head. This upper part of the eye is likewiſe very hard underneath and in the middle, but it is ſoft above, where the cornea tunica is placed. The horns are compoſed each of three joints, whereof the largeſt are thoſe which are joined to the head on each ſide of the eyes; from theſe the horns inſenſibly grow very ſhort, and terminate as it were in ſmall briſtly hairs. In this thin and tender part of the horns I reckoned above one hundred and twenty very fine and delicate articulations, each of which was likewiſe adorned on each ſide with two pair of fine hairs. In the larger Crabs theſe articulations are very diſtinctly conſpicuous, and when the Crabs are boiled, the horns may be divided into as many plain and ſmooth rings as they have articulations of that kind. Between the firſt and ſecond joint of theſe horns of the Hermit, there is a ſmaller rigid or hard appendage, beautifully adorned with briſtly hairs.

Between the horns, under the eyes, appear a beautiful pair of rough hairs, which conſiſts of three joints, whereof the upper one is the broadeſt. Under theſe are ſeen the teeth, which are two little, hollow, white, oblong bones, and are furniſhed with ſtrong muſcles, wherewith they are moved. Between theſe teeth is placed an external bone, by which the creature takes its meat, for which purpoſe it has not only two arms or forceps *e*, *f*, but many articulated rough or briſtly hairs, of different ſtructures, which cover the mouth on the lower part. There are two very ſmall, ſmooth, broad, ruddy, ſhaggy briſtles, or rough hairs of this ſort, each of which has one joint only. There is afterwards another pair of larger briſtles of the ſame conſtruction, each of which has two joints. There is alſo a third pair, not ſmooth or broad; but with theſe, on either ſide, are two pair of ſuch little parts likewiſe articulated, and every hair of this third part in the ſame manner conſiſts alſo of two joints. The fourth pair is ſomewhat ſmooth and broad, and theſe are compoſed of three joints; to theſe are alſo joined another pair, each hair of which has two joints. There is in like manner a fifth pair, that are likewiſe double, that is, a larger one, compoſed of four joints; and the other, which is joined to the former, conſiſting of three. Laſtly, there are underneath, near the thorax, a very large pair of briſtly hairs, like two legs, each of which conſiſts of ſix joints, and has alſo on each ſide a ſmall part added to it with two articulations. So that computing the whole, there are here twelve pair of ſmall parts beautifully interwoven with briſtly hairs, which meet together when the Hermit ſwallows its meat, as is manifeſt from their ſtructure and ſituation.

The thorax underneath is divided in the middle as it were by two teſtaceous little bones, with which the two arms and the four fore legs, Tab. XI. fig. I. *gg*, are articulated. And in order to ſee this diſtinctly, it is neceſſary to take the whole Hermit out of the ſhell, and to lay it on its back. Then four articulated briſtly hairs are ſeen between the eyes. fig. II. *aa*; but the other briſtly hairs before deſcribed cannot be ſeen diſtinctly, until after theſe are removed out of their places, becauſe they are covered by them. Near the eyes two horns *bb* come in ſight, and afterwards two arms are ſeen very diſtinctly, of which the left with its forceps *c*, is always leſs than the right *d*, though both are compoſed of five teſtaceous joints; to the uppermoſt of which is likewiſe joined by articulation a ſmall part, which may be called a thumb, and from this the forceps of this creature have their origination.

The four ſubſequent legs *e e* conſiſt of ſix joints, which are alſo like the arms adorned with prominent notches, briſtly hairs, ruddy ſpots and furrows. And further, with the thorax are

are joined two other pair of fmaller parts like legs: and in the middle, between each pair of thefe, are obferved fome peculiar little bones, whereby thefe legs are joined to the thorax. The firft pair of them, Tab. XI. fig. II. *ff*, has indeed five joints, and, in other refpects, it is of the fame ftructure with the arms or forceps, and has, like them, a very fmall thumb. The other pair likewife confifts of five joints, and is very worthy of notice *gg*, becaufe the firft pair of thefe joints, that next to the thorax, or the fifth, if you compute from the extremities, is perforated with two fmall tubes, iffuing from the abdomen, through which the femen or eggs are fecreted; which indeed deferves very great confideration. The upper part of the thorax, or back, is furnifhed with a fmall fhield; behind which is placed fuch another, but lefs. On the fides of the thorax the cruftaceous covering of the back is thin, and if it be raifed up, which may be done without diffecting it, the branchiæ or gills are obferved underneath, placed on each fide of the thorax.

The abdomen is foft, and has no fhelly or cruftacious covering; fince the fhell itfelf is its coat, and does the office of that hard fkin. The body is in this part bent near the duct of the fpiral windings of the fhell, with which it is furrounded. But this bending of the body is not fo remarkable as in Snails; becaufe the body of the Hermit is not extended through all the turnings of the fhell. The abdomen has on the right fide three teftaceous briftles *hhh*, each of which confifts of two joints. Rondeletius, in his Hermit, feems to delineate fix fuch little parts, which are interwoven or planted with little eggs or fpawn like beads.

Among many things worthy notice in the belly, what deferves moft particular confideration is a certain eminent or prominent point *i*, which is naturally the firft thing obferved in the thorax, and is as the center, wherein all the tendons of the mufcles, and that part of the abdomen meet; and by the help of which, the Hermit is in that part fixed in his fhell or ftony fkin, fo that it can never go entirely out of it. Though its thorax, and the hinder part of the abdomen and the tail adhere to nothing, and that there is fuch large room or fpace in the fhell, as that the Hermit can freely move itfelf therein; yet the thorax is forced to remain fixed in the fhell, like the Tortoife in its houfe or fhell.

The tail of the Hermit is alfo furrounded with a cruft *k*. That this may appear the more plain, I have delineated it larger than it naturally is. This tail confifts of two teftaceous articulations, Tab. XI. fig. III. *a*, to which are added at the end a verge as in Snails *b*, which forms the third joint, and ferves to hide the fundament: for the inteftinum rectum *c* terminates there in the fecond joint. On each fide of the tail are three pair of teftaceous little bones *dd*; which, like the arms, are larger on one fide than on the other, and beautifully decorated with fmall hairs. The Hermit makes ufe of them when it finds an enemy approaching, to hide itfelf in the fhell, or when it defires to reft; for then by their affiftance it lies fixed in the hinder parts of the fhell, or draws itfelf back into it. But if the Hermit draws to it, or contracts thefe little parts, it can then protrude its tail forward into the entrance of the fhell, and thus it evacuates its excrements. For this purpofe, I think, nature has given it fo large a fhell; the hinder windings whereof are not all filled with it, as we have before obferved. The fame is found in Snails that inhabit fhells; which, for that reafon, difcharge their excrements through their neck, and have not a very moveable tail. Thefe little bones of the tail are formed, fome larger than others, in proportion to the fpace in the fhell, for this is larger on one fide than on the other. In the fame artificial manner are built the wheels of french chariots made for afcending.

The internal parts.

Receive, illuftrious fir, this brief defcription of the external parts of the Hermit Fifh, and permit me now to pafs to the internal, beginning with the abdomen, becaufe I have begun the diffection there. When the abdomen is opened, the firft thing that appears is the outer and inner fkins, which are glandulous; and immediately under there is feen a flefhy membrane. After thefe integuments are diffected or taken off, a great number of whitifh filaments prefent themfelves; which are delicately and orderly placed on very numerous and beautifully digefted parts, in form refembling inteftines, fig. IV. *gg*. As I purfued the courfe of thefe white filaments to their origin, I faw they were blood veffels, though of a white colour like a cob-web. What I firft took to be the inteftines were all appendages *, fometime plain, and fometimes divided; which were of a tubular ftructure and whitifh colour, and contained a matter feparated into diffimular parts, and condenfed into a ferum and coagulum. Thefe appendages were fo numerous as to cover almoft all the abdomen; but they were all connected by the blood veffels, which I was obliged to break open with great attention, in order to difcover their origin and beginning. Thus I at length difcovered that thefe were on each fide united, Tab. XI. fig. V. *hh*, into two common ducts, which grow near the ftomach where the pylorus is placed, and are terminated in many unopened tubes *ii*. What ufe thefe appendages are of, and whether they ferve inftead of a pancreas, which is formed in that manner in many Fifh, may be more accurately inveftigated in the larger Crabs.

* This is a conftruction very frequent in the inteftines of Fifhes.

Among these appendages, at the bottom of the muscles of the abdomen, appeared an intestine; which, without any winding, ran strait from the stomach towards the tail; and whereof I have here delineated, fig. III. *e*, only a small part, somewhat augmented beyond its natural size. It was full of gray excrements, which, when viewed with a microscope, consisted almost entirely of small chrystals, which were regular grains of sand. The stomach also contained partly the same substance, and partly some little fibrous membranes. Its upper part is placed near the back, its inferior in the thorax. It is in structure partly membranous, and partly crustaceous: its bones are very beautiful. Above, below, and on each side, it has many muscles, by which its parts are connected and moved. On the inside, in the cavity of the stomach, I saw three distinct teeth, of a moderate size, each of which was divided into several smaller teeth: the teeth were of a pale lemon colour, but it was changed by degrees into a dark green, in that part where they terminated in little teeth or divisions. Two other teeth-like little parts, which were uneven and notched, adhered also to the cavity of the stomach. This observation is certainly very worthy of notice, that the little creature, living like a Snail in the shell, is furnished with a double apparatus of teeth; for it has two teeth forward in the extremity of the mouth, and five others in its stomach.

Where the intestinum rectum or straight gut begins, I saw the cæcum or blind gut moderately long, and beautifully twisted, Tab. XI. fig. III. *f*, which I first took for the extreme appendage; but as I found it loose and disengaged in all the Hermits I dissected, I therefore believe it is the cæcum. I should not, however, venture to affirm this for certain, because I have not distinctly seen its blind or imperforated extremity; for all its contents were coagulated and separated by the spirit of wine, and the place wherein the intestine itself was seen, appeared so transparent, that I could not observe that particularity. Besides, it was not like the appendages on account of its contents, nor was it inserted in the middle, but somewhat on one side of the intestinum rectum.

In the abdomen, on each side of the appendages, there were two small genital vessels, fig. VI. *a a*, whereof that in the right side was the larger: both were, in many places, beautifully twisted into spiral windings *b b*, and they proceeded thence curled, till they at last terminated in a narrow tube *c*. It appeared likewise how these, in their end, pierce or perforate the last pair of legs, fig. II. *g g*, in the middle of the fifth joint, which resembles a bone or shell with a considerable tube, fig. VI. *d*. This I have delineated larger than it naturally is. This perforation appeared to me very plain, when I squeezed the contents through it, and separated and unbound the tube itself. In it was a substance of a whitish colour, and when examined with a glass, it seemed all to consist of very small regular little parts, like round globules. I could not discern whether these were the rudiments of eggs, or the globules of a male's semen; since in all the ten that I dissected, the same structure was observable in the genital vessels. The windings of these spermatic ducts were likewise connected by means of blood vessels; and when I opened them, they were ten inches and an half long. These are all the entrails that I saw in the abdomen; only that in the bottom of the belly were placed several muscles, towards which the nerves issued from the spinal marrow. Part of the tendons of these muscles terminated in the point, fig. II. *i*, above described; where the creature is fixed in its skin or shell, so that with their assistance, the Hermit may draw in and hide itself in the shell. Between the appendages I saw many little drops of fat floating, which resembled the oil boiled out of the fat of Whales swimming in water.

If the thorax be opened above in the back, the first part that is there seen is the stomach, with its muscles, which is of a remarkable size in this creature, and is really situated under the back, though I have, for method sake, described it in treating of the abdomen. Behind this stomach, above the place where the intestine arises, is situated the heart, Tab. XI. fig. VIII. *a a*, which resembles an irregular little piece of flesh, and becomes somewhat pointed. It is of a ruddy colour there, but underneath and at the sides it is white. I perceived four vessels *b* issue from it above, and two *c* below; and one of the two lower ones was larger and thinner than the other; which however consisted interchangeably of somewhat thicker sides, and sent off some vascular sprigs *d*. On the outside of the surface of the heart I observed *b* several little holes; but on the inside the heart was fibrous, and furnished with its pillars or columns like the human heart. I discovered only one venticle in this creature, as is the case in the generality of Fish; but I could not see its auricle. Moreover, I observed how the whitish vessels in this heart, were distributed up and down through the body, especially towards the branchiæ or gills, one of which I have represented magnified *e*.

There are here, as I have observed, eleven branchiæ or gills on each side of the body, so that they make twenty-two in all. They are situated at the sides of the thorax, between these long cavities, which there form the articulations of the legs. They are of a pyramidal figure, rising from a broad basis *f*, and ending in a small pointed top *g*. Each of them is, at the upper end, divided into two other parts, each of which consists of a great number of smooth or plain lamellæ *h* or layers, which are applied close to each other like the leaves of a book, and each of them is divided from the others very deeply, which makes indeed a very agreeable sight. The structure of the branchiæ or gills is partly cartilaginous and partly membranous; and their blood-vessels veffels are extended near the cartilages. Moreover the beginnings of the appendages are feen very beautifully in the thorax, as has been before obferved.

After thefe little parts, together with the ftomach, heart and inteftines are removed, the fpinal marrow prefents itfelf to view: it is placed entirely at the bottom of the thorax, and is not inclofed in a bone. It extends itfelf through the lower parts of the abdomen to the tail of the creature, and there terminates in the mufcles of that part. In order to defcribe this matter the more exactly, it muft be obferved, that the brain, Tab. XI. fig. IX. *a a*, from which this marrow arifes, is fituated immediately under the articulations of the eyes in the head, which is very fhort, and joined to the thorax. This brain is feen to be there divided into a right and left part. Above the brain appear the optic nerves *b b*, which are found to decuffate over it, and to proceed towards the eyes, as I fhall now fhew. Underneath, out of the bafis of the brain, arife two ftrong nerves *c*, which properly conftitute the origin of the marrow in the thorax: thefe nerves are placed at a confiderable diftance from each other, in order to give a paffage to the gullet, which is very fhort, and reaches from the mouth to the ftomach. The brain is therefore placed over the gullet, and the gullet again, as well as the ftomach and inteftine, are lodged upon the marrow in the thorax and abdomen. Thefe two originations of the marrow are again united a little below, and there form a remarkable fwelling or knot *d*, out of which many nerves iffue, which are diftributed over the mufcular parts of the thorax as well as the brachia and legs. In men and quadrupeds fuch clufters are never feen in the body of the marrow, but always in the nerves after they have iffued out of that part; but this is indeed the fame thing in effect, for as the marrow itfelf is as it were a bundle of nerves, and is double in all fpecies of animals, it is the fame thing whether thefe clufters are found in the marrow, which is a kind of thick and compound nerve, or in the nerves iffuing from thence, which are the feparate portions of the marrow. Whoever accurately confiders the marrow in man and other animals, will indeed moft clearly obferve this analogy; though Malpighius himfelf does not feem to have obferved it, when he fuppofed there was fo great a quantity of brains in the marrow of filk worms. After the marrow has formed this clufter in the Hermit, it becomes fimple again, though its two parts may, notwithftanding, be palpably diftinguifhed; but thefe are fo nearly applied and contiguous to each other, that they are as if they were but one. Afterwards is difcovered another clufter of marrow, and a third, fourth, fifth, nay, a fixth, *e e e e e*; the nerves of this laft are detached to the mufcles of the tail. The nerves which arife out of thefe little clufters, are almoft all beftowed on the mufcles of the abdomen; whereas on the contrary, thofe that iffue from, the marrow itfelf, Tab. XI. fig. IX. *ff*, are likewife diftributed to the vifcera. It is likewife worthy of notice after what manner the nerves decuffate one over another, which I demonftrate in thofe nerves which iffue before the laft clufter out of the marrow *g*, and are detached to the mufcles of the abdomen.

After the optic nerves have iffued from the brain, they are inclofed in the annular *h* cruft of the eye, and being again confiderably expanded in the latter, they thus proceed to the verge of the cornea tunica, and there terminate like fpheres, or in globular forms. No humours appear any where in the whole eye, like thofe found in the eyes of men, quadrupedes, birds, and terreftrial or water Snails; but it is obferved to be of a texture entirely different, which is very worthy of attention. If the cornea *i* be taken from the eye, there is immediately feen under it a kind of limpid matter, fig. x. *k*, which is the colour of jelly, and is divided in a very elegant and regular manner. What part this is, and whether it has its origin from fpirit of wine, I cannot exactly determine, as I never faw any thing like it in any infects, whofe eyes are of the fame ftructure. I fhall therefore at a proper time examine this little body, in the larger Crabs diffected alive.

But before I proceed further, it is to be known, that the cornea tunica is divided like a net, in the fame manner as in the eyes of infects, but thefe reticulated divifions are here much deeper. I find every divifion to be hexagonal, as well in this Hermit as in infects. Moreover, all thefe divifions wind themfelves above in a fpherical figure, which however is not here very remarkable, fince the ariolæ or little beds of the divifions, are very fmall and fmooth. On the infide, in the hexagonal cavities of the divifions of the cornea, was fixed the glutinous matter before defcribed, which was there divided in the fame manner as the cornea itfelf. Under the latter appeared a great number of little fibres, fig. IX. *l*, which are placed on the internal furface of the eye, in the fame manner as the feeds of the plant turnfol are fixed in their cups. All thefe fibres, which fupport the glutinous matter aforefaid, are connected together by the help of a membrane of a black colour on the infide, but above of a tranfparent green on account of the matter; I therefore call it the uvea tunica.

The ftructure and fituation of thefe formed as it were an inverted pyramid, with its fmall point turned downwards; but when I feparated thefe little fibres from each other, they appeared above as black as pitch, Tab. XI. fig. x. *m*, but below only of an obfcure or dark brown *n*, and pellucid in the middle *o*: all of them terminated at length in a gray fubftance, and under this the extremity of the optic nerve came in fight.

When I viewed thefe fibres with a microfcope, I found each of them confifting of other

other fibres, fig. XI. *pp*, all which were compofed as it were of regular globules placed near each other. Between thefe little fibres there appeared alfo fome fmall membranes, interwoven likewife in feveral places with globules, between which fome veffels appeared creeping in various directions.

The cornea tunica, which is entirely pellucid, is very beautifully fituated on this eye, and fhews a greenifh tranfparent uvea underneath: where the eyes face each other, the cornea is beautifully divided, fig. IX. *i*, and the cruft is there extended further; fo that the cornea is placed on the eye like a little cap, lying on the head obliquely.

After what manner fight is performed in the eye of the Hermit, and what effects are produced by the rays of light which pafs through the cornea, and the glutinous fubftance, and are afterwards ftopt by the uvea, and thence communicate their motion to the pyramidal inverted fibres; this, illuftrious Sir, I leave to your difcerning and moft correct judgment, not doubing but you will give me the folution of fo peculiar a problem.

What I have here briefly related, Sir, is all I have been able, in this fhort time, to difcover in thofe Hermits, which the governor of Nyenrode fent me in fpirit of wine. I offer you thefe obfervations in token of, and to preferve, our mutual friendfhip, and as an example of the divine miracles, which ought to be adored in all animals. Indeed, if we diligently fearched into nature, we fhould for ever find more remarkable and more ftupendous miracles, which hitherto lie hidden and wrapped up in the clouds of our ignorance. I hope to be at fome time able to go through an accurate examination of the Caterpillar kind; in which, indeed, mifery, death, and the grand and fplendid refurrection of the body may be fo clearly demonftrated, that we fhall fee them as it were painted before our eyes, and muft be obliged to cry out in amazement, that the great God, the parent of all nature, exceeds and furpaffes all praife, all eulogies, and all titles of honour, in his miracles, which can never be defcribed according to their dignity.

The SECOND ORDER.

Of the natural changes, or of the flow accretions in the limbs and parts of Infects.

HAVING explained the firft clafs of natural transformations in infects, we fhall now pafs to the fecond, which, though fomewhat more obfcure, may yet with due attention be clearly and diftinctly underftood. But before we proceed to explain this fecond clafs, to which innumerable infects are to be referred, it is neceffary to obferve, that in this order another fpecies of transformation conftantly precedes, which is indeed common to the two following, which are the laft claffes of mutations.

In order to underftand accurately the preceeding kinds of tranfmutation in this, as well as in the two laft claffes, we muft call to the attentive reader's mind what has been faid in the beginning of this work, where we treated of the firft kinds of changes; that is, that fome infects iffued perfect out of the egg, and others imperfect. As we have referred the infects, which come perfect from the egg, to the firft clafs of tranfmutation, it is very neceffary to know, that this fecond, and afterwards a third and fourth, or laft clafs of mutations, precedes the completion of the parts in thofe which iffue imperfect in fome of their parts out of the egg. Hence it is, that in the firft order or clafs of changes, is peceived only one Nymph as it were, which we have obferved is the egg or little creature itfelf. In the fubfequent claffes, on the contrary, we fhall obferve as it were two Nymphs in the courfe of the changes, and therefore two fpecies of thofe changes alfo fince another kind of Nymph precedes the egg, or the oviform Worm of the Nymph.

That all thefe things may be perceived the clearer, we muft briefly obferve, that a little Worm always precedes this fecond and all the fucceeding orders of tranfmutations. After this Worm has been in its egg or firft cover in the form of a Nymph, it increafes by degrees in its limbs, and in procefs of time becomes fo perfect, that at length it puts on another habit of a real Nymph, and again becomes fluid like water in all its parts, and weak and feeble, or deftitute of ftrength, as it was before, when it was in the form of an egg. Hence it has happened, a matter not hitherto obferved, that not only the ancient errors concerning thefe metamorphofes remain to this day, but even thofe moft diligent fearchers into nature, the fagacious Francis Redi and others, declare they have feen the caft skin, under which all the limbs and parts of the infect increafed; but never doubted concerning the metamorpofes, at which we greatly wonder.

To fpeak now in particular of our fecond clafs of changes, it will be very proper to obferve, that the accretion of the parts undergone in procefs of time by the Worm, which is commonly found to have fix legs, is infenfibly and by degrees perfected by the evident external addition of matter; fo that after fome changes of its skin, we at length obferve wings to fprout infenfibly out of the body, to fwell and become fit to open and bloom, as a tender, small, soft, delicate hull of a flower does out of a plant. Again, as in the other two changes, under which we shall see the Vermicles or Worms transformed into real Nymphs, the insects are deprived of motion, and as it were of necessity lie unmoved for some time; so on the contrary, the insect, under this change, advances, stands, walks, runs, leaps, and eats, nor is it ever deprived of motion, only that it rests a little at the time it is to cast its skin; and then stupendous changes happen in some of them, as is sufficiently manifest in the Ephemera, or Day-fly. In others, on the contrary, the change is so inconsiderable, that it is with great difficulty observed, only about the protuberant wings, as is the case in the Earwig.

Since therefore the insects which come under our second class of changes, are not at any time deprived of motion, and yet have some of their parts well ordered, and compounded like other Nymphs: for these cogent reasons we are induced to think, that the insect may, at the time it exhibits its limbs and parts in the manner aforesaid, not improperly be called a Nymph-vermicle; for the little creature, whilst it is and remains a real Vermicle or Worm, has notwithstanding some of its parts disposed, and in an admirable manner beautifully composed, just as they are in the Nymph state.

Our second order or class of changes is therefore thus; the Vermicle or Worm having cast off the habit of a Nymph, which it bore, without food in its egg, increases insensibly by the help of food supplied from without, disclosing many and more visible parts, until it afterwards puts on as it were the form of another Nymph; but this without losing its motion, and it afterwards comes out of that as a winged insect; and having now attained as it were the marriage-state, becomes fit for generation.

This is the species of Nymphs, to which we have given the second place among the natural orders of changes, since the mutation in question is not very intricate, nor is it obscure or difficult to be understood; nay, it may with these rules be comprehended easily, and it approaches very nearly to the first order or class of changes, wherein we saw the creature issue immediately out of its egg or coat; nor does it indeed differ greatly from that order.

As this change is so clear and evident, and as it agrees so much with the budding and blooming of a flower, we have therefore thought proper to compare this, and the other subsequent changes, to this budding of plants. This is the more proper, because, as the increase happens on the outside of the creature, so it is likewise observed to happen in other insects on the inside, and under the skin; which has been sufficiently shewn in the preceding pages, and shall be explained more at large hereafter. To conclude, as this change is very elegant, and very worthy of consideration, it comprehends also a great many insects under it.

A catalogue of the insects, which are referred to the second order or class of natural changes, called the Nymph Vermicle *.

TO this our second order or class of changes we refer first the Dragon-fly, called the Mordella, or Orsodæna, by Junius; by Mouffet, Libella; and by Aldrovandus, Perla. I preserve seventeen species of this genus, nine very large, five of a middle size, and three very small ones, which, because they are tender and delicate, are dignified by some under the particular name of Virgins. One of the smallest species is well described by Goedaert, but as this author neither delineates in its figure, nor takes any notice in its description of those swellings in the back, wherein the wings are inclosed, it is evident he did not know the nature or disposition of this Nymph. Besides, the third figure which he gives us of it, misrepresents nature according to the fancy of an imaginary brain. I never could find that it has hitherto been described by any other author. Among the figures published by Hoefnagel, who has given us the delineations of ten species of the Dragon-fly, there is found none of the Nymphs before mentioned; it is certain, however, that they were in general not unknown to authors. We find that Rondeletius knew the Nymph of the Dragon-fly, though he very improperly called it the Cicada or water Grasshopper. In like manner we believe that the Mordella is the water Locust of Mouffet. This is most certain, that the Forficula Aquatica of Johnson, or otherwise the Pulex Marinus of Mouffet, is the true Nympha of the Mordella. The Scorpius Aquaticus also of Redi is nothing else but the Nymph of the Perla or Dragon-fly, but belonging to a species which we reckon among the larger Virgins.

I keep in my collection, six kinds of the Nymph Vermicle, from which Dragon-flies have their origin; there are one very large, three of a middle size, and two small. I have likewise a Dragon-fly, which was to have undergone a change immediately, and in which one may observe, in what a wonderful manner the wings are wrinkled and folded in the tubercles on the back, wherein they are enclosed. I preserve besides the ovary of the Dragon-fly, which is perfectly like that of fish, divided into two parts, one whereof is placed in the right, the other in the left side of the abdomen.

* The famous insect, the Formica Leo, is a Vermicle of one of the Flies of this kind. This creature naturally walks backward. There is another species which moves forward; these are found on land. The more frequent kinds are those of the water, and they are common in our ditches.

The fecond infect which we reckon in our fecond clafs of changes is the Grafshopper. I preferve one and twenty fpecies of them male and female; thefe are nine larger, fix middling, and as many fmaller ones, whereof fome are confpicuous by their fcarlet wings, others are cloathed in purple, others in azure, and others have elegant greenifh wings. I preferve alfo fome Nymphs, fome Vermicles, and fome little eggs, from which proceed the Grafshopper and Locuft kinds. Amongft the largeft fpecies, I have the great deftructive African Locuft, which has a cowled or hooded breaft, and two very long legs, which, as they have hexagonal thighs, are provided alfo with a double row of ferrated and long teeth; the internal wings glitter with a deep purple colour. This belongs to thofe fpecies, which do not fhew their colour except when they are flying. I have alfo the Locuft of the Molucca iflands, which Dr. Padbrugge fent me. It has a very flender body like the Cavallucus of Redi, and the tail is bent downwards. Its wings are long, and of various beautiful colours like the Peacock. The neck is of uncommon length, and fupports a fhort head. That gentleman fent me alfo a figure of the Molucca Bruchus, or Grub, the body whereof is as big and as thick as a Hen's egg, and is beautifully interwoven with veins like ribs, but the legs are very fhort in proportion. I preferve with thefe the Spanifh Locuft, which differs from the African only in its fize, except that the veins in its wings are difpofed in a different manner, and the colour is reddifh. I have alfo the African Locuft with fhort legs, and fhort thick horns, wherein one may, in a remarkable and diftinct manner, fee the prominent eyes. Among the middle fpecies I preferve the Mantis or divining Locuft, which was likewife brought from the Molucca iflands. Of this authors invent many idle ftories; one is, that when it is afked the way by travellers, it fhews it. "This little creature is reckoned "of fuch a divining nature, fays Mouffet, that "when a boy asks for the way, it ftretches its "foot forward and fhews it, and is feldom or never miftaken." The other Locufts that I preferve are of the middle fize, and moftly french; they are adorned with a wonderful variety of colours, as with fo many new-fafhioned garments: hence they pleafe the eye greatly with their natural ornaments, but they do not fhew their colour except when they fly.

It is remarkable what fmall difference there is between the Worm or Nymph Vermicle of the Locuft, and the Locuft itfelf: this confifts only in one thing, that the wings, which in the Locufts are expanded and fpread over the body, are on the contrary enclofed in the Nymph, in four little clufters, wherein they are quite folded into each other, in like manner as in the Worm of the Dragon-fly. It was this folding and feparating of the wings, that, in my opinion, made Ariftotle, Pliny, Hieronymus, Aldrovandus, Mouffet, Johnfon, and other curious fearchers into thefe fecrets, call the aforefaid Vermicles of Locufts, featherlefs or unfledged Locufts and Bruchi. The fame creatures they afterwards, when their wings began to fwell, called Attelabi; and to thefe, when by the increafe of the bulk of their bodies, efpecially thefe of the females, they began to hop flowly, but were not yet able to fly, they gave, not to mention many other names, the appellation of Afelli. The word Attelabus properly fignifies the Nymph of the Locuft when able to walk. We fee feven fpecies great and fmall of thefe Nymphs, out of which the Locufts iffue. In the figures of the induftrious Hoefnagel, which exhibit fifteen fpecies, we likewife fee there a delineation of the Nymph Vermicle of the Locuft. When I confider all thefe experiments, I cannot imagine for what reafon Goedaert fhould write, that Locufts had their origin from a Chryfalis; fince Aldrovandus and Mouffet, and all other authors make mention of unfledged Locufts, and their opinion is fupported by, and agreeable to, experience.

I preferve alfo a three-fold ftomach of a Locuft, which is very like the ftomachs of animals that chew the cud, and particularly has that part of the ftomach called Echinus, very diftinctly vifible. I do not therefore doubt but Locufts chew the cud, as well as the animals juft mentioned: indeed, I perfwade myfelf that I have feen this.

I have likewife in my poffeffion, the oblong eggs of Locufts and their entire ovary, which is interwoven with filver-coloured filaments, which are doubtlefs ramifications of the afpera arteria, and alfo with veins and arteries. But the eggs are all as it were horny, and of a brown colour: many of their firft rudiments alfo being white and yellow, and covered with a thin coat or skin. I preferve thefe in particular cells in my cabinet.

The female Locufts are furnifhed with fharp tails, which the males have not. According to Aldrovandus, they pierce the ground with thefe tails, and bury their eggs under it. I can demonftrate this tail to be quadruple, nay, quintuple.

I preferve alfo the teeth of Locufts, and the coat or skin which the Nymph Vermicle cafts, when the wings of the Locufts begin to fwell. No man can form any idea, by what means a very thin skin is then feparated from the long and fmall horns of the Locufts; nay, and from the eyes and teeth, and the fharp-pointed claws. In this period the Locufts are fo foft and delicate, that their legs may be bent like wax, and formed into any figure, and in that condition may be dried and preferved.

I have alfo wings of Locufts which I ftopped in the act of their exclufion; fo that by this means one of their extremities is difplayed or rolled out, and the other ftill folded together and wrinkled. With thefe wings the Grafshoppers and Locufts, when they have gone through their change, make that crackling noife, as Cafferius has very juftly obferved. We alfo find that

that the males of Locufts only make this noife, not the females: indeed fome fpecies make this noife with their wings only, and others by ftriking their wings and legs together.

The Locufta Pulex, or Flea Locuft, follows. This little creature is found hid in that fpumous matter, which we fometimes fee lying indifcriminately on the furface of all kinds of plants*. In this fpume † it acquires in time four tubercles on its back, wherein the wings are enclofed. I have two fpecies of this infect, and it was likewife known by Mr. Ray, who defcribed the plants growing about Cambridge. It has not teeth like the Locufts, but has only a fubtle fharp-pointed probofcis or trunk, like Grafshoppers, on its breaft.

We refer alfo to this fecond clafs the Gryllus Sylveftris, or wood Cricket; in which infect we alfo obferve that the male only fings, or makes a noife. I remember that I once faw a whole field full of thefe finging Crickets, each of which had dug itfelf a hole in the earth, two fingers deep, and then fitting at the entrance thereof, they made a very difagreeable noife with the crafhing and tremulous motion of their wings; when they heard any noife they immediately retired, trembling, into their little caverns.

The houfe Cricket is the next to be reckoned in this fecond clafs; fince this, like Locufts, has alfo its wings enclofed in little cafes, as long as it remains in the habit of a Nymph.

We likewife rank the common Grafshopper in this clafs. For although the larger Grafshoppers are not found in our part of the Netherlands; we, notwithftanding, by inference from the lefs to the greater, refer them to this place; and the rather, becaufe the very diligent Aldrovandus hath left us a delineation of this Worm, with its tubercles on its back, wherein the wings like a flower in its cup are enclofed; as this Worm is called Tettigometra by him, it is the real Nymph of the Grafshopper. I preferve a very rare and curious exotic Grafshopper, the head of which is formed like a long and deep epifcopal mitre, fo that it appeared four fifths of an inch above the eyes, exhibiting us a wonderful work of God in the theatre of nature. We muft alfo obferve again, that the male Grafshoppers only can fing, and we can fhew their tympanum, and alfo the little part that modulates or tunes the voice, or impels the air againft the tympanum.

The Gryllo Talpa or Mole Cricket, or the Talpa Ferrantis Imperati, likewife belongs to this clafs; fince, like the infects hitherto defcribed, it has four tubercles on its back, wherein the wings are enclofed. We have the Worm of this infect with and without tubercles, as alfo the infects themfelves, with their wings difplayed. The induftrious Goedaert has defcribed the egg of this infect. We can alfo fhew its teeth, and the manner wherein the wings lie complicated in their tubercles.

In this I alfo reckon a little creature, which is found in the tubercles of the leaves of the black poplar, though I might have defcribed it in the fourth order or clafs, becaufe it has a more fecret method of changing. It is delineated in figure XXIV. of Tab. XLV. To this order I likewife refer another infect, which is likewife reprefented in fig. VII. of Tab. XLIV. and is found in the tubercles or fwellings of willow trees.

The next we exhibit is the Indian infect, fufficiently known by the name of Kakkerlak, which we think likewife belongs to this fecond clafs. As we have obferved the tubercles beforementioned in its wings, though not having attained their full bignefs their wings did not appear perfect; for the fame reafons, we think we fhould refer to this order that fpecies of Beetles which are commonly found about bakers ovens, and, according to Fabius Columna ‡, in kitchen dirt. They agree altogether with the infects juft now mentioned, called Kakkerlak, and are the fame that are defcribed by Mouffet under the name of Blattæ. We preferve two fpecies of them, together with their Nymphs, wherein the tubercles fcarce began to fwell.

Next follow the flying or land Bugs, which we find in fields and trees. I preferve twenty-fix fpecies of them in my mufeum, together with a larger Indian one, which are very beautifully adorned by nature with variety of colours; and as with their luftre and gaiety they wonderfully pleafe the eyes, fo they are very difagreeable to the fmell. Hoefnagel alfo has figured eleven kinds. Among thefe which are in our cabinet, we reckon the cruciate, the fcarlet, the red marked with black lines, the green, the black, the yellow, the globular, and that which has a fharp-pointed breaft.

To this clafs we likewife refer the flying water Cimices or Bugs, of which we preferve four full-grown ones, and one Nymph. Thefe, like all the reft, carry their weapon in their mouth, and fting vehemently therewith, as I have fometimes experienced myfelf, though I fuffered no injury thereby.

We refer alfo to this order or clafs fome infects that are very tender and flow-paced, having fix flender and admirable legs, and long and acute horns, and a confiderable thick body; from the hinder part whereof, about the tail, fpring two briftly and fharp-pointed hairs, and they have likewife a fharp fting, as the Cimices

* This is a fpecies of the Cicada or Cigale. The characters of that genus are very obvious on it: they are, that the beak is under the breaft, and is bent downwards; the antennæ or horns very fhort; the wings four, and placed crofs-wife, the back concife, the breaft cylindrical, and the legs made for hopping. The Cicada of Italy, which the Roman poets mention, and which their tranflators render Grafshopper, is of this genus. We have alfo one on the rofe, and others on various bufhes.

† This fpume is not exfudated, as fome fuppofe, from the plant, but from the mouth of the animal; and if it be well wiped away, without injuring the creature, more will be immediately feen iffuing out of its mouth, till there is as large a quantity of it as before.

‡ Obf. aq. et terr.

or

or Bugs, ſo that they ſeem likewiſe to belong to that genus. I could never hitherto obſerve theſe little creatures to change: but they are found on various plants, and there become often immoveable. Laſtly, I preſerve a very ſlender kind of Fly, which firſt iſſues from a Worm which was in the body of that creature, tranſformed into a Nymph of the third claſs. But if this Fly creeps out of the body of this inſect, after preparing a paſſage for itſelf through a ſmall hole which it makes with its teeth, then all the body is hollow, and the dead inſect remains in the ſame ſituation as if it were ſtill living *. Theſe little creatures, hitherto not accurately enough examined, are improperly called the Lice of plants. I have ſome of them, and alſo the flies that come from them.

We likewiſe place in this order the water Tipula, of which I preſerve many ſpecies, and one of the Nymph. Theſe inſects are worthy of the greateſt attention, on account of the wonderful lightneſs wherewith they run on the ſurface of the water. They have an aculeus or ſting, like Bugs, in their mouth. I preſerve beſides another ſpecies of this inſect, which is of a wonderful delicacy, and of a very ſingular ſtructure, and very ſlow-paced.

In like manner we inſert in this claſs the water Scorpion, which has alſo an aculeus or ſting in its mouth. I preſerve two ſpecies of it, the larger whereof is deſcribed by Aldrovandus under the name of the water Tipula, and the leſs by Mouffet retaining the name of the water Scorpion. I have a Nymph of the ſmaller ſpecies, in which may be ſeen how the wings bud or diſcloſe themſelves by degrees, as is the caſe in the Nymphs of the Dragon-Fly in this ſame claſs.

The common water Flies are likewiſe of this order. Of thoſe I preſerve four ſpecies, and we have often ſpoken of the Nymphs and Worms out of which they iſſue when ſmall. Theſe, like other water inſects, likewiſe have their ſting in their mouth, and they defend themſelves therewith, whenever they are attacked or taken. Theſe Flies are called amphibious Bees by Aldrovandus, and are very accurately deſcribed by him. They are alſo called wild Bees by Johnſon: nor do I doubt but theſe are the ſame with the Marinæ or Sea Bee, which has been deſcribed by Dr. Piſo, and is now in the poſſeſſion of Vander Linden, doctor of phyſic; but it appears to be nothing elſe but a piece of ſponge. The learned Mouffet calls theſe Flies Notonectæ, becauſe they do not ſwim on their belly, but on their back; and he ſeems to have likewiſe delineated the water Bug among the Notonectæ, ſaying, that it is probable men learned the art of ſwimming on their backs from them. How far this may be admitted, let others determine.

As all the inſects hitherto enumerated have wings, ſome of them flying in the day-time and others at night, it is eaſy to conceive that they may be very ſpeedily generated in all ſtanding waters. And therefore in ſummer-time a kind of trembling motion is frequently obſerved to be excited even in the ſmalleſt ditches of water by the motions of inſects. But we ſhall ſpeak of theſe matters more at large in their proper places.

Laſtly, we likewiſe refer the day Fly, Ephemera, to this order: its eggs and ovary, which is like that of fiſh, we preſerve in our cabinet. We alſo have in our poſſeſſion the Worm and Nymph Vermicle, and alſo the Ephemera itſelf, both male and female. We can from theſe objects demonſtrate how the wings are rolled and folded in the tubercles of the Nymph Vermicle, for there is an admirable difference between the folds of theſe wings, and the complication of the wings of the Dragon Fly. We alſo obſerve the like difference, with reſpect to the diſpoſition of the wings in other inſects, as will be ſhewn from our particular obſervations, to the praiſe and glory of the moſt admirable Creator. After this, we ſhall in its place, from the courſe of our experiments, aſſign a reaſon, why the wings in theſe inſects are diſpoſed in ſuch a particular manner, the knowledge of which will doubtleſs be acceptable to the reader.

I preſerve likewiſe the one day Flies, fixed in ſuch a poſition, that it is very eaſy to perceive the method whereby they caſt a very thin ſkin like a ſhirt from their whole body, which is wonderful to look upon, and difficult to be expreſſed in words. At one end of this ſkin they roll or turn themſelves out, as the foot is taken out of the ſhoe, and at the other end they turn it off in the ſame manner as a man takes off his glove by turning the inſide outwards. All this will become evident, when we deſcribe our particular obſervations on this ſtupendous miracle of the Netherlands, and what we have remarked concerning the uncommon, very ſwift, and as it were horary changes of this little creature; that they may afford perpetual matter of meditation on the incomprehenſible wiſdom of God, and regular order of nature. In the mean time, we think what Dr. Augerius Clutius hath not ſcrupled to affirm, very improbable; and that is, that the Ephemera, or day Fly, is produced from a Chryſalis, and he has likewiſe exhibited the figure of this Chryſalis contrary to all truth. We obſerve that its figure is ſubjoined or added alſo to the track of Goedaert; but theſe are delineated upon the ſuggeſtions of a weak fancy. This will be very evident, when the inſects themſelves, which the learned Andrew Colvius ſent us, are compared with thoſe figures.

* Since the time of this writer, Reaumur has with great judgment and knowledge written of many of theſe creatures. They run about the branches of trees and ſhrubs, while ſmall, and when they have paſſed part of their lives thus, they remain immoveable for the reſt, and their bodies become only a kind of covering for numerous genus. That author calls them gall inſects, and progal inſects. The Kermes and Cochineal are of the ſame kinds.

I have

I have in my poffeffion feveral fpecies of the Ephemerus collected in France and other places; among which I can fhew the leaft fpecies of the Hemerobius or Ephemerus, called in Dutch Mut; the wonderful changes whereof I have fhewn as a matter of the higheft fpeculation, to the moft noble Thevenot, the illuftrious patron of all our ftudies, in the road that leads from Amfterdam to Sloten.

Before we conclude this order, we fhall refer the Earwig, Forficula, or Auricularia thereto, which creature, with its wings vifibly expanded, and its Nymph-Vermicle are alfo preferved in my collection.

We clafs or arrange in this order all the infects that we have hitherto defcribed, which are excluded from their eggs under the form of a Worm, and in procefs of time are augmented or increafed into Nymph-Vermicles and fo on. Nor can we fufficiently wonder that this order of change has not been hitherto obferved or reprefented to our knowledge by any perfon. So that upon confidering how little the naturalifts have taught us concerning thefe creatures, we are obliged, not without fhame, to confefs, that they were wholly ignorant of the nature of moft infects. For, if we may exprefs the matter as it really is in a few words, the names only of the faid infects are mentioned in the books of the naturalifts, and if you except thefe, nothing remains but the falfe and imaginary inventions of a dreaming and chimerical brain. As I am not afraid to declare this generally, I would always except the induftrious Goedaert, who has faithfully delineated, and, in fome meafure, according to truth defcribed the changes of the Caterpillar kind; as alfo the moft accute Redi, who has, by irrefragable arguments, proved, that no creatures are produced by putrefaction; and laftly, fome accomplifhed Englifhmen, the chief of whom are John Ray and Martin Lifter.

An example of the fecond order or clafs of natural changes, which I call the Nymph-Vermicle, in the Dragon-Fly.

N°. I. I EXHIBIT here, Tab. XII. the Vermicle or Worm of the Dragon-Fly, as yet lying in its firft coat, in which, when enclofed, it is called an egg. Many of thefe eggs, placed near each other in the fame manner as they are fituated in the divided ovary of the Libella, I here exhibit delineated to the life. This ovary perfectly agrees with that of fifh, efpecially that of the Herring, and confifts in like manner of numerous eggs, which are of an oblong figure, as may appear from thofe difperfed here and there in this figure. The eggs enclofed in this ovary are at length thrown into the water by the parent infect, out of which afterwards iffue many fmall Vermicles with fix legs; and thefe having attained the full period of their growth, caft their skins, and becomes fo many Dragon-Flies, like the parent.

II. To fhew the method wherein this happens, I have likewife, for the fake of order, delineated to the life the coat of the egg out of which the Worm of the Fly has made its way.

III. I afterwards in the third place, fhew the Vermicle or Worm from which the Dragon-Fly is produced, by the power of accretion alone, but I have not delineated it fo fmall as it is when it comes firft out of its egg, but fomewhat larger, and in the form it has when it has been fed for fome time. I fhew its eyes, together with two prominent horns in its head: in the breaft underneath are obferved fix fhaggy legs, each of which is divided into four joints, and the extreme joint of each is furnifhed with two claws. The belly is divided into ten rings, the laft or loweft of which has fome briftly, rigid and prominent little points. It is agreeable to obferve in this Worm how its limbs come imperfect out of the egg, which is likewife a property of the Vermicles of the third and fourth order or clafs of tranfmutations, as fhall be afterwards fhewn in its proper place. And it is for this reafon I call the little creature, whilft it remains in this imperfect form in the egg, an oviform Nymph-Vermicle, as I have explained more at large above; and this obfervation I would have inculcated and underftood once for all, in the courfe of the fubfequent orders, as I fhall repeat it no more.

IV. I reprefent this Vermicle fomewhat older, fo that about the end of the thorax, where that part is connected with the belly, four membranous buds or follicles like flower-cups are obferved to fpring, fwell, and as it were branch out of the body: thefe four follicles or membranous bags contain the wings, which increafe in the fame manner as the cups of plants and trees do with their flowers and fruit. But if any one fhould at this period diffect thefe bags, he would find nothing in them but a watry humour or ichor, becaufe the wings, too tender yet for fight, have not acquired their ftrength and perfection, in the fame manner as in the cups of flowers and fruits when they are firft diftinguifhable, nothing is found but a moifture or clammy liquor.

V. I afterwards demonftrate this little creature in the ftate wherein it has attained its full bignefs, together with its four bags or follicles, which are confpicuous on its back, and are increafed to their due fize; at this time I find the wings perfect in them, but folded in each other; nay, we may likewife obferve all the colours and varieties of painting of this creature now tranfparent through the skin:

wherefore, as the infect is and remains yet a Vermicle or Worm, and has fome of its parts enclofed in a skin and deprived of motion, like a Nymph of the third order or clafs, I have called it in this period a Nymph-Vermicle. In what manner this Nymph cafts its skin, is fhewn in the fecond figure, Tab. XII. fig. 11.

VI. Laftly, I exhibit the fame Vermicle as it is when arrived to its laft degree of perfection; in which form it is called the Perla, Libella, or Dragon-Fly, and by increafing becomes a perfect creature, becaufe it has acquired its full age and is now fit for generation. As at firft it was a creeping and fwimming Worm, it is now become a flying Worm or inhabitant of the air. Moreover, its change, or properly the accretion and expanfion of its parts, is, with refpect to its eyes, wings and tail, extremely admirable, but the legs undergo no change.

I firft obferved thefe Worms, out of which the Dragon-Flies are produced in the river Loire at Saumur, behind the houfe of the very learned Dr. Tanaguil Faber, whofe gueft I had then been, and who likewife greatly loved to fearch into fuch natural miracles. I afterwards found them in many other frefh rivers, fmall pools, fenny ditches, and other ftanding waters, and in fome places in fuch great numbers that the whole bottom was as it were planted with them. They can both creep and fwim, but they do not move fwiftly. They have likewife a fharp fight, and they immediately throw themfelves to the bottom, if any one comes to the places wherein they live, or when they perceive the leaft uncommon object. Their food is foft mud, and a fine earthy fubftance; wherein they live. They are produced by the Libellæ or Dragon-Flies, for thefe are likewife ufually about waters, and in thofe places perform in a very wonderful manner the bufinefs of generation. Numerous Dragon-Flies are likewife found in the fields and forefts, where there are numerous fmaller Flies; for, like birds of prey, they hunt after and devour the latter in the air.

If the eggs which the Dragon-Flies throw into the water be examined with a microfcope, they appear of an oblong figure, Tab. XII. fig. 1. and in the fore part terminate in a point: in this part they are alfo adorned with a kind of little cups, with protuberant points, fomewhat refembling the cups which we have delineated in the Nit or Loufe's egg, and they are blackifh in the extreme fore end. At the hinder part the egg terminates in an oval form, and has a glittering furface; befides this it has nothing fingular in it.

When the Worms which iffue out of thefe eggs have grown to the form of a Nymph-Vermicle, they then remove out of the water to a dry place, as into the grafs, to pieces of wood, or a ftone wall, or any thing elfe they meet with; and therein firmly fixing the acute claws, Tab. XII. fig. 11. *a a*, of their legs, they continue immovable a very fhort time. It is then obferved, that the skin firft opens in their head and back; and out of this opening they exhibit to view their real head and eyes *b*, and at length their fix legs *c c*; whilft in the mean time the hollow and empty skin or flough of the legs remains firmly fixed in its place; after this the enclofed creature creeps forward by degrees, and by this means draws firft its wings and then its body out of the skin, and proceeding a little further, fits at reft for fome time longer as if immovable. In this time its wings begin by degrees to expand themfelves, and to make fmooth and even all their plaits and folds. The body is likewife infenfibly extended, until all the limbs have obtained their juft fize and bignefs. As all thefe things are perfected by the force of blood and circulating humours, and by the affiftance of the air impelled by refpiration, the creature cannot the firft moment fly, and therefore is forced to ftay in the fame place, until all its limbs are dried by the circumambient air and fun. Thus the Dragon-Fly enters upon a more noble life than that it had hitherto led in the water, for in the latter it was obliged to live in mifery, creeping and fwimming flowly, but now it wings the air.

It is very feldom that thefe changes of infects are prefented to view by nature, and it happened by mere chance that I obferved them for the firft time: one of thefe Vermicles adhered to a ftone wall in the river Loire, and it was fo foftened by the waves dafhing againft it, that it could only half perfect its change, fo that I took it partly free, and partly yet fixed in the skin. I once afterwards faw this change in the large kind of Dragon-Fly, which had crept to land out of a fmall lake, and caft its skin fitting in the grafs. In the fmalleft Dragon-Flies, which are very numerous in Holland, and of which Goedaert has defcribed the mutation, it is not fo difficult to difcover this matter, as I have long ago fhewn it to many, and amongft the reft to Dr. Matthew Slade.

Another thing worthy of obfervation in thefe creatures is, that they muft hunt and feek after their food flying in the air, for which purpofe nature has given them two large eyes, which make almoft the whole head, and are like glittering mother-of-pearl. They have moreover four remarkable membranous filver-coloured wings, with which, as with oars, they can turn themfelves like fwallows with a prodigious velocity to all parts of the air. But to this the very long tail that they have is alfo conducive, for with this they fteer and govern themfelves with great art, and prepare themfelves a certain path through the air. Mouffet, who erroneoufly afferted, that thefe creatures were produced from rotten bull-rufhes, fpeaks however very rationally of them, when he fays: "They form one of the greateft beauties in all "nature, being fuperior by far to all art."

The eyes of the Dragon-Fly are of a reticular ftructure, and are divided by a double feries of interfections, as I have defcribed in another place. Within the mouth are to be

feen

feen two teeth, covered with a beautiful lip; with thefe the creatures bite fiercely when they are taken: and it was probably for this reafon that Junius gave them the name of Mordellæ. But whether their bite be venomous, or raifes a blifter in the skin, I have not hitherto obferved.

Since the Dragon-Flies have very large and long wings; and, on the contrary, very fhort legs in proportion, it is not agreeable to them to walk on the ground, and the more, becaufe when they walk, they do not raife their wings, nor keep them clofe on their back, like the Butterflies. For which reafon they always choofe dry branches of trees, on which they pitch when they want to reft or have catched their prey, which they feize with their fix legs in the air, convey into their mouth with their two foremoft legs, and then break it in pieces with their teeth. In this they do not fpare the melliferous Bees; they catch them in the air and deftroy them. Thefe Flies cannot be kept alive long in a box, unlefs they are fed every day with Flies, which they like to eat. They are greatly delighted with the rays of the fun, to which they are indebted both for life and motion; for, when the heavens are cloudy, and the air obfcure, they reft and do not eat, having then very little motion.

The thorax, on the infide, where the wings are fixed to the fhoulder blades, exhibits a large number of mufcular fibres, which ferve to move the legs and wings. Through thefe fibres pafs the heart, gullet, and fpinal marrow, the greateft part of which are placed in the loins and belly. But as I have not hitherto perfected the exact anatomy of thefe creatures, I cannot advance any more particulars concerning them. The ftomach is fhaped like a pear; I have once feen it full of food, and at another time full of air. The pulmonary veffels are likewife numerous here. One may likewife diftinctly fee the mufcular fibres, which I never faw agitated with any remarkable motion.

The male hath its penis placed about the beginning of its belly, the female on the contrary has the orifice of the vulva, in the extremity of her tail; but I have not accurately viewed thefe parts, fince, in order to make the diffections, I fhould have taken out the entrails of thefe infects firft, that I might preferve the whole form of their bodies. This may be eafily done, if one takes out the vifcera, and afterwards fprinkles the parts, which are ftill wettifh on the infide, with plaifter of Paris, or unflacked lime, which imbibes the moifture. By this means a very elegant fpecimen of the tail, breaft, and eyes, may be preferved; and this contrivance is likewife made ufe of by painters and engravers. There is upon all thefe occafions a neceffity for a cautious and circumfpect dexterity, which cannot be acquired but by frequent exercife, and is not to be taught by words.

Though the Dragon-fly is, in every refpect, a wonderful creature, and has its genital organs placed in a very fingular manner in its body; its act of coition in particular exceeds or furpaffes all the powers of our imagination. The male, fluctuating and rifing up and down in the air, and cutting it with many convolutions, knows how to ftretch or hold out its tail with wonderful velocity to the female, Tab. XII. fig. III. *a*, who places it between the divifion of her head and eyes, and guides it into her neck, and then, clofely embracing it with her legs, receives it very pleafingly *b*; then fhe immediately bends and turns her body toward the breaft of the male *c*, where the mafculine organs of generation are placed near the upper part of the belly; and thus continually flying and panting, they perform the bufinefs of coition in the air. By this means the extremity of the female's tail is bent back, towards the middle of the male's body, that is toward that part where the penis lies, which is received by the vulva of the female, placed in the top of her tail; but that the female may the more conveniently reach to that part, the male fhortens himfelf as it were, and bends and contracts his tail confiderably.

The female being thus impregnated, after fome time dips her tail into the water, and throws her eggs into it. Thefe eggs, as I have already obferved, are oblong, and while they are fmall and imperfect, they are fomewhat tender and whitifh, but afterwards they by degrees grow hard and yellow, having a blackifh point at their end. How long fuch an egg remains in the water before the Worm is produced from it, is as much unknown to me, as how long it is increafing from that time until it changes its skin; but I fhould think two years are neceffary for this purpofe, fince I have obferved that thefe Worms were at the end of the fummer very far from a ftate of perfection. I have fometimes feen in France fo great a number of them in a clayey ditch that had no water plants in it, that they covered the whole bottom.

Of the various fpecies of the Nymph-Vermicles of the Dragon-Fly.

AS I have obferved in the general enumeration of thefe creatures, that I kept fix of the Nymphs, one of which I have before delineated, Tab. XII. N°. v. I fhall now reprefent and briefly defcribe four others. The firft belongs to one of the largeft Dragon-Flies, in the head whereof are obferved two equal, but not reticular eyes, fig. IV. *a a*; before thefe are placed two horns *b b*, and under the latter may be feen the three divifions of the mouth, whereof the two upper are provided with teeth *c*, which may be moft properly called fo, only I think them too delicate and tender. Underneath at the breaft are fituated fix legs, which have two

two ſharp claws *dd* at their extremities, and are variegated with green, yellow and other coloured ſpots. In the upper part of the back, under the ſhoulder-blades, may be ſeen very diſtinctly four membranous cups, wherein are encloſed *ee* the wings folded into each other; ſo that it is hard to underſtand how or by what means ſuch ſtrong, broad, long and remarkable wings as the largeſt Dragon-Fly has, could be contained within ſo narrow a compaſs. But this matter will be eaſily underſtood by any perſon who attentively conſiders what a large number of leaves lie folded up in the globular cup of the double poppy; for the wings beforementioned agree very well with thoſe leaves in the manner of their lying.

The abdomen is divided at the margin of the belly into various ſharp and rough diviſions *ff*, the rings whereof are, where they branch out, adorned with many tranſparent colours. The tail is divided as into five parts, which, whilſt the little inſect lives, reſemble ſo many pyramidal rough prickles or ſtings *g*, each of which caſts it ſkin, when the Nymph aſſumes the form of a Dragon-Fly: theſe ſerve principally to cloſe up the fundament, and are likewiſe an ornament to the hinder part of the body. But in the males they have another uſe, that is, to keep the creature in coition firmly fixed to the head of the female, and join themſelves with the neck of the latter, as I have exemplified in the third figure of the middle Libella, Tab. XII. fig. III. In my laſt obſervations I alſo remarked, that the branches or ramifications of the Aſpera Arteria likewiſe ſhed a coat or ſkin: and in this reſpect it agrees with all other ſpecies of Nymphs, and with the Worms and Caterpillars of Butterflies and other inſects.

The other Nymph Vermicle that I exhibit is likewiſe of this ſpecies, from which the middle Dragon-Flies are produced. It has all thoſe parts I have before ſhewn in the largeſt. The lips only and teeth are placed in a different manner, and are obſerved to be longer, fig. V. *a*, though they may be likewiſe lengthened or drawn out in the largeſt Nymph. The legs alſo are ſhaggy *b*; the follicles or bags are likewiſe diſtinctly ſeen on the back *c*, as well as the rings of the abdomen, and prickles or ſtings in the tail *d*. I found the former largeſt Nymph in a ditch upon ſome water plants, after it had firſt crept into the graſs and caſt its ſkin. In the Nymph juſt now deſcribed the wings were ſo perfect, that they might be ſpread open or diſplayed in the hand.

The third ſpecies I exhibit is not found in Holland, except in the diſtrict of Utrecht. I firſt found this Nymph on the other ſide of Paris in the river Seine, where many ox skulls had been thown into it, and theſe being filled with mud afforded the Nymph habitation and nouriſhment. I likewiſe found there many river Hermits, which probably prey upon theſe and the like inſects. This is probably the little creature that Redi calls the Marine Scorpion, and delineates without follicles or bags of wings, becauſe he had not ſeen it completely perfect. Of the ſame nature with this inſect is alſo that which Rondeletius calls the Marteau and river Libella. In the head of this inſect are likewiſe obſerved two eyes, without diviſions; before which are two articulated horns or antennæ, fig. VI. *a*. It has ſix legs, which are long enough for the bigneſs of the body *b b*. The four bags or follicles annexed to the ſhoulder-blades are preſſed together cloſe and even; and are beautifully marked, Tab. XII. fig. VI. *c c*, with intercurrent veſſels. The body is divided into rings, and is all over briſtly *d*. The tail was painted with green and yellow, and divided as into three triangular appendages *e*. This little creature ſwims faſter than the former Nymph; but the Fly again iſſuing from it, has a ſlower motion, and prides itſelf in very beautiful wings, which are variouſly painted, according as theſe Nymphs differ among themſelves. Whoever attentively views the wings of this Dragon-Fly, will ſee that their nervous diviſions are much cloſer than in the wings of the largeſt and middle ſpecies; nay, this differs from them in this, that it folds its wings like the diurnal Butterflies, when it lies any where to reſt.

I have a Spaniſh Dragon-Fly, which has ſharp pointed wings, and therefore differs from all others; for the wings of ours are for the moſt part oval, and terminate in a roundiſh extremity. It has likewiſe very large hairy horns or antennæ. I have myſelf delineated to the life another kind of Dragon-Fly ſent from Africa, which had ſpotted wings. I likewiſe have ſeen a third ſpecies, which had very long and broad wings, and but a ſmall body in proportion: but the wings were conſpicuous and remarkable for ſome paintings on them like dried vine-branches, and exhibited a ſpectacle of the moſt exquiſite art and admirable elegance. I have therefore delineated this in its natural ſize, and can ſhew a preparation of it to this day.

The fourth ſpecies of theſe Nymphs is found every where in the waters in Holland, but eſpecially in the narrow ditches; out of which, with the water plants, ſuch Nymphs may be taken almoſt every year, not excepting even the winter. They do not differ much from that juſt now deſcribed, as is manifeſt from the figure, fig. VII. This Nymph, having caſt its skin, produces a very ſmall Fly, with ſilver-coloured wings, and a blue and black body. This kind has alſo a ſlow motion, and almoſt perpetually flies about ditches. This ſpecies of Dragon-Fly has the ſame method of generation with the largeſt and middle kind, for both perform the buſineſs of coition in the air. But I muſt confeſs I never ſaw the manner wherein theſe Flies that iſſue out of the Nymphs delineated in fig. VI. propagate their ſpecies.

Of the flying Water Scorpion *, *which belong to our second class or order.*

THE EXTERNAL PARTS.

OF the water Scorpion which I occafionally mentioned in the general enumeration of infects, I have not feen more than two kinds. Thefe I fhall now feparately defcribe with figures, to illuftrate the defcription. The firft, which is the fmalleft and moft common of the two, is, like the greateft part of the other more perfect infects, divided into a head, a thorax, and an abdomen. In the head are placed the eyes, and under thefe is the mouth, which is of a round form, Tab. III. fig. IV. *a*. The head is of a pale red colour, and of a very hard and firm texture. The eyes are hexagonal and reticular. The fting which lies in the mouth, as in a fheath, is hollow, and of a bright red colour. In the upper part of the thorax, which refembles the head both in colour and texture, we find four wings, and in the lower part as many legs, befides two claws placed forward towards the head. The upper wings *b b* are of the fame colour with the thorax; and it is remarkable, that the fore parts of thefe, by which they are joined to the fhoulder blades, are of a ftronger and firmer texture than the hinder parts, which are in a manner membranaceous, and full of delicate veffels. Thefe upper wings are inferted fo clofe to the lower pair, and cover them all over fo exactly, that at firft fight no one would imagine the infect had two pair. This difpofition of the wings preferves the under pair from getting any wet, though the creature fhould remain a whole day under water. Thefe under wings are of a pale colour *c c*, and of a membranaceous texture, with little yellow and red veffels or pulmonary tubes moft elegantly diftributed through them. The upper part of the abdomen, which thefe wings cover, is of a deep and clear red colour, like vermilion, and is thick fet with hair, fo as to afford a very agreeable fight. The legs have feveral joints, and each ends in two claws *dddd*. Thefe are almoft of the fame fhape with thofe of the land Scorpions *e e*, only they have no forceps or pincers; but the firft point is fo flexible, and the infect has fuch a command of it, that it ferves the fame purpofe. The abdomen, whofe fhape has been already defcribed, is underneath of a pale colour, and terminates in a forked tail, which when opened, is exactly like the figure I have here given of it *f*. The thorax and abdomen of this infect are fo unufually flat and thin, that one would be apt to fufpect nothing was contained within them †.

There is nothing more remarkable in this infect, than that it conftantly appears covered with a prodigious number of nits of different forts and fizes, though perhaps we may with more reafon confider them as fo many little creatures, which live and grow by fucking the Scorpion's blood. Thefe are fomewhat of an oblong figure, approaching to round, and have a fhining, and as it were bloated furface, without any of the rings obfervable in moft infects. The neck is oblong and fhaped like a pear, with the fmall end fticking in the Scorpion's body. The colour of this infect is a mean between that of vermilion and purple; and when it is pretty well grown, there appears within it an elegant tranfparent fpot or particle, Tab. III. fig. IV. *g*.

This fpot or particle induced me to confider with more attention this minute and hitherto unregarded infect, and even to undertake the diffection of it. But who would imagine that on this examination it fhould prove a perfect and furprifing infect? This is however a certain fact: and thus in that infinite variety of works, by means of which God is pleafed to make himfelf known to us, we ever meet with new matter of admiration and aftonifhment.

This little creature being extracted from the fhell that covered it, looks like a young Spider before it has left its egg. On the fore part is the head, fig. V. *a*, and on its head are the eyes *b*: under the eyes are placed its little legs elegantly coiled and folded *c c*; but they appear much more diftinctly on turning the infect on its back *d d*; and in this fituation alfo it beft appears with what art thefe legs are laid up in the fhell, and all over covered with hair. The colour of this little creature is, as I already obferved, a mean between that of vermilion and purple; and this colour fhews itfelf through the coat or fhell, which is tranfparent. I cannot determine to what fpecies of infects this is to be referred; nor can I fay to what fize it grows, or by what kind of creature it is thus depofited on the water Scorpion in the form of an egg, there to receive life and growth. Neverthelefs, I cannot but look on the difcovery I have made as very interefting, fince it proves that there are in the nature of things eggs which acquire a fenfible growth by an

* The characters of the water Scorpion according to the latter fyftems are thefe: the trunk is turned in under the body, the antennæ or horns form a kind of claws like thofe of cruftaceous animals; the wings are four, and they are placed crofs-wife; and the legs are four. Linnæus connects the Cimex Aquatilis with this, and gives to the genus he thus forms the name Hepa.

† There is not perhaps in all the animal creation fo outrageous or fierce a creature againft thofe weaker than itfelf as the water Scorpion. It deftoys, like the Wolf among Sheep, twenty times as many as its hunger requires. I have feen one of thefe when put into a bafon of water, in which were thirty or forty of the Worms of the middle Libella, which are at leaft as large as itfelf, deftroy them all in a few minutes: he gets on their backs, and pierces his trunk through their body.

entraneous nouriſhment, unleſs perhaps ſome naturaliſt ſhould chooſe to conſider this as a complete inſect, rather than as an egg: nor ſhall I ſtrenuouſly oppoſe this opinion, ſeeing that in all caſes the egg is in reality no other than the inſect itſelf, which remains in that ſtate till it has acquired ſtrength ſufficient to break its priſon, and live without ſuch a covering.

THE INTERNAL PARTS.

AMONG the internal parts of the water Scorpion, the organs of generation ſeem to be thoſe which beſt deſerve our attention, and which I have accordingly moſt attentively examined. The contents of the ſtomach and inteſtines were of a green colour, but thoſe viſcera when emptied appear of a tranſparent white, with here and there ſome tranſparent glandules of the ſame colour. Behind the pylorus are ſome varicous or knotty veſſels. The abdomen is all over covered alſo with particles of fat of a moſt bright white, which look as if they were divided into many appendages of the nature of the inteſtina cæca.

The number of pulmonary tubes is here very conſiderable, compared with that which is ſeen in the generality of other inſects. The larger branches of theſe tubes are of a yellowiſh colour, and the ſmaller of a ſilver white. Their openings lie under the wings on each ſide of the abdomen. The breaſt contains two air bladders. The ſpinal marrow conſiſts of very few joints.

The parts of the male ſubſervient to generation appear of a moſt delicate and exquiſite contrivance, ſo as to deſerve our moſt ſpecial notice; and the diſſection of them took me up ſo much time and attention, that in taking drawings of them I at firſt overlooked the penis. This is placed backwards near the inſect's anus, where there are ſeveral other parts worth examining. The root or nervous body of the penis, Tab. III. fig. VI. *a*, which is of a white colour, lies a little higher up in the abdomen, I have repreſented it here as it appears when taken out of the body. This root of the penis, after having made many ſerpentine turns, divides into four tubes, two of which conſtitute the vaſa deferentia, whilſt the other two perform the office of the veſiculæ ſeminales in other animals, and open into the cavity of the root of the penis, where they diſcharge the matter prepared by them. I have given an exact drawing of the vaſa deferentia; one of them I have repreſented as it appears moſt curiouſly convoluted in its natural ſtate *b*; the other as it looks when drawn out *c*. Theſe vaſa deferentia are conſiderably wide and ſpacious, but not equal to the veſiculæ ſeminales. It is probable theſe veſſels are adapted by nature to ſecrete a ſeminal matter different from that prepared by the teſticles; for they are largely ſupplied with glandules to anſwer that purpoſe, and conſiſt of a conſiderably thick and ſpongy ſubſtance. As the vaſa deferentia approach the teſticles, they grow leſs and leſs by degrees, ſo as to form two ſlender tubes *d d*, and this portion of them alone ſeems to claim the name of vaſa deferentia, as they do nothing but convey the ſeed from the teſticles: theſe teſticles conſiſt each of five diſtinct bodies, ſeparated on all ſides, oblong, white and glandulous *e e*, with which are united as many ſeminal veſſels twiſted and coiled one over another very elegantly, and in a great variety of directions *f f*. I have repreſented one of them as it appears when ſeparated from the reſt, and extended *g*. The veſiculæ ſeminales are ſomewhat ſhorter *h h*, but they are a little wider than the vaſa deferentia. The former contain an aqueous ſeminal matter, which in the teſticulary veſſels, the glandules of the teſticles, and even the vaſa deferentia themſelves appear of a ſhining white. From this we may conclude that the mechaniſm of theſe genital parts reſembles greatly that of the ſame organs in the Rhinoceros Beetle, which I ſhall hereafter deſcribe. Indeed in reſpect to the vaſa deferentia, the teſticulary veſſels, and the veſiculæ ſeminales, they are not unlike thoſe of the human ſpecies; and this reſemblance is very worthy our notice, in order to diſcover the general analogy between animals by a careful compariſon of their organs, as exhibited to us in accurate diſſections.

Among the parts of the female ſubſervient to generation, the moſt conſpicuous is a ſurprizing kind of ovary, divided on each ſide into five oviducts, one of which I ſhall here repreſent, and in part the reſt being ſimilar, fig. VII. *a a*. The eggs contained in theſe oviducts are of ſo curious a ſtructure, and placed with ſo much art, wiſdom and judgment, that I muſt own I never met with any thing contrived more nicely, or more elegantly diſpoſed. That this contrivance and diſpoſition may appear the more diſtinctly, I ſhall firſt deſcribe the egg itſelf, which in ſhape greatly reſembles the ſeed of the carduus benedictus. This egg is a little oblong, of a yellow colour, with its lower ſurface ſomewhat convex, fig. VIII. *a*. The edges of the upper ſurface are elegantly adorned with ſeven ſlender branches, not unlike ſtiff briſtles very red at the points *b*, and white in the middle *e*, ſo as to afford a very entertaining appearance. That theſe briſtles may be in no danger of creating confuſion in the ovary, or of wounding it, or the eggs, or receiving themſelves any damage by bending, the briſtles of the firſt egg, or that which is next to the aperture of the ovary, lie flat againſt the edges of the ſecond egg, ſo as to form a kind of bed for the lower and convex ſurface of it *c*. The third *d* and all the other

other eggs are orderly placed in the ſame manner, ſo as to afford ample matter for admiring and adoring the all-ſeeing Architect, who ſo wiſely formed and diſpoſed them.

Theſe water Scorpions live in the water all the day, out of which they riſe about the duſk of evening into the air, and ſo flying from place to place often betake themſelves in queſt of food to other waters. This is always their courſe when the ditches in which they inhabit, come to be dried up. This affords us a ſatisfactory reaſon for the great number of inſects that immediately appear in the ſmalleſt collections of water, ſince they may very well get thither when it is dark; ſo that the opinion which aſcribes to putrefaction the power of forming inſects, muſt by this inſtance of the water Scorpion's nocturnal tranſmigrations appear more and more frivolous and unneceſſary. I have in fact been told by a perſon who took great delight in fiſhing, that he has found the eggs of ſome kinds of Fiſh ſticking to the wings of Ducks, who by this means he with great reaſon imagined might ſerve to repleniſh the waters on the top of the higheſt mountains with the inſects proper to that element.

The Nymph of the water Scorpion remains in the ſame place where it was produced, till the wings are full grown, when ſhe immediately ſallies forth in ſearch of a companion of the other ſex, with whom ſhe may carry on the great buſineſs of propagation, and multiply the ſpecies.

The Water Scorpions of the larger ſpecies differ but little from the ſmaller, which I have hitherto deſcribed. The body of the larger kind, Tab. III. fig. IX. *a*, is much longer and ſharper than that of the other; and its limbs are more diſtinct and conſpicuous. It is alſo of a paler colour, ſomewhat more gray, but inclining to red. As to the claws in this ſpecies there is in them ſomething very remarkable; the joints from which they ſpring are furniſhed each with two ſharp proceſſes *b b*, in order to receive, and as it were ſheath theſe ſharp claws when bent againſt them. The legs alſo are much longer, and are made like ſtiff and ſlender briſtles *c c*; but the membranous extremities and ornaments *d* of the wings differ greatly. I have not examined the internal parts of this ſpecies.

The natural hiſtory of the inſect called the Hemerobios, Ephemerus, or Diaria, extracted from J. Swammerdam's account of it, formerly printed in Dutch under the title of, The Life of the Ephemerus.

WE ſhall leave out in this extract all the pious meditations and religious ſentiments with which the original is ſo liberally furniſhed, as they would ſwell this work into too large a bulk, and do not properly belong to the deſign of it as a natural hiſtory. The author publiſhed at that time his obſervations on that ſurpriſing inſect, to give us wretched mortals a lively image of the ſhortneſs of this preſent life, and thereby to induce us by the help of frequent admonitions to aſpire to a better: and we hope we cannot in juſtice be accuſed of defeating his well-meant labours by abridging them in this manner, ſeeing his book, which he himſelf publiſhed, is ready to be had by any one that chuſes to read every thing he has ſaid on this ſubject. It contains alſo a great number of Dutch ſentences in verſe, and in proſe, of which it would be almoſt impoſſible to give a proper verſion fit to appear in public; and to interrupt the work with Dutch quotations, would be ſpoiling the regularity of the work. That the illuſtrious Thevenot, whom Swammerdam himſelf firſt charged with the edition of this work, intended to proceed in the ſame manner, appears very plainly from a French tranſlation of the natural hiſtory of the French Ephemerus, which has fallen into our hands amongſt other manuſcripts relating to this ſubject. We ſhall therefore proceed in this deſign of giving the reader all that relates to its hiſtory, and nothing more, without any further apology.

CHAP. I.

The Ephemerus is produced from an egg *.

THIS inſect, Tab. XIII. fig. XV. has four wings, two little antennæ or horns, ſix legs, and a very long and hairy tail; it lives at the utmoſt but five hours. This ſurpriſing creature appears every year for three day ſucceſſively fluttering on the ſurface of the water, at the mouths of the Rhine, the Meuſe, the Wael, the Leck and the Yſel, about the feaſt of St. Olophius and St. John; but this continued appearance is kept up by a ſucceſſion of them

* The Ephemerus, for ſo it is the eſtabliſhed cuſtom now to write the word, conſtitutes a diſtinct genus among the four-winged Flies. The characters are, that there are two large prominences for the eyes on the upper part of the head; that the tail is furniſhed with ſome briſtly hairs, and the antennæ are ſhort. There are ſeveral ſpecies of this genus of different ſizes.

them, for thofe which begin to live and flutter towards the noon of the firft day, are dead before night, and the fame happens the fecond and third days; which being expired, no more of them are to be feen till the returning year again renews this three days wonderful fight.

At this time the female of the Ephemerus, fig. VIII. after having thrown off her coat or flough, iffues from the water and difcharges into it both her ovaries, Tab. XV. fig. III. But this is not done till fhe has for fome time fluttered upon the furface of the water in a very curious and furprifing manner, beating it with her wings all the time.

It is at this time the female like a fifh difcharges her eggs, which the male, Tab. XIII. fig. XV. who firft quits the water, and afterwards divefts himfelf on the land of a very thin skin, fig. XIII. and XIV. invigorates by ejecting on them his melt or feminal milky fubftance.

I fhall in the fucceeding pages defcribe in a full and accurate manner how this act of generation is performed, how thefe infects rife from the water, and how they free themfelves both in the water and on the land of their old skins.

The firft time I obferved this furprifing infect, was in the year 1661, on a branch of the Rhine running by Culenburg. But Clutius who has likewife written of thofe infects, fays they are to be found at Aarnhem, Zutphen, on the canal called Vaart near Utrecht, at Rotterdam, and in many other places. Doctor de Mey, a moft reverend and learned divine, has likewife given us an exprefs treatife on this fubject, as appears by the appendix to Goedaert's hiftorical obfervations. Nor has the obfervation of thefe infects been confined to our times, fome of the greateft naturalifts of antiquity have made mention of them, as appears by Pliny, Ariftotle, Ælian, and others who have written on thefe fubjects. We find this little creature defcribed in their works by the name of the Hemerobion, Ephemerus, and Diaria, as appears by many paffages in their works, as likewife by Augerius Clutius's work, publifhed in the year 1634, of which I juft now made mention.

The eggs of the female Ephemerus dropt into the water, and there impregnated by an effufion of the male's fperm, in the manner we have defcribed, gradually fink to the bottom. But this is effected in fuch a manner, that the eggs are fcattered over the muddy bottoms of rivers by the motion of the waters. The figure of the eggs themfelves does not a little contribute thereto, as they are of a plain convex fhape, Tab. XV. fig. I. and are thereby the apter to difperfe in their defcent. This appears by placing a few of them on the point of a knife, and then letting them fall gently into water, for they immediately feparate of themfelves in a very curious manner.

It is hard to fay, and God only, who gives thefe infects life and motion, knows how long their eggs lie at the bottom of the waters where they are depofited, and how long it is before the contained infects break through the fkin that furrounds them, and perform as it may be called their firft moulting. It is not improbable that thefe things might be experimentally afcertained by dredging for them at different feafons, or keeping their eggs in a veffel full of water with a fufficient quantity of mud at the bottom. For the prefent we muft be fatisfied to obferve that the eggs of the Ephemerus produce, after an unknown time, a little Worm with fix legs. This is the creature fifhermen call the bank-bait.

CHAP. II.

The egg of the Ephemerus produces a little Worm with fix legs, called the bank-bait by fifhermen.

ON fearching the bottoms of waters frequented by the Ephemerus, fome time after it has laid its eggs, we find a multitude of little Worms with fix legs, which differ in nothing but fize from thofe that are more grown. But this is not to be found till a long time after the parent infects have made their appearance, for the growth of this little infect is fo flow, that in the beginning of June in the year following, about which time the bait turns to an Ephemerus, they are fcarce three quarters of a Dutch inch long, Tab. XIII. fig. I. which is but about the third part of the length of the full grown Worms, fig. III. that have complete wings, and are juft upon the point of making ufe of them.

Befides two kinds of Worms remarkably differing in bignefs, a third is obferved to be produced at the fame time from the mud, fig. II. which is bigger than the leffer kind by almoft two thirds, and is a third part lefs than the largeft kind. Nor is this difference between thefe Worms in refpect to their various age, all we obferve, for thofe of the fame age differ greatly both in length and thicknefs. When the largeft kind of thefe Worms is about three thumbs breadth long, in the beginning of June, when they are about to begin to fly; the middle kind is not completely two long; and the fmalleft is fcarce a thumb's breadth in length.

There is another remarkable difference between thefe Worms of the Ephemerus, which is, that the fmalleft kind, fig. I. not only is without wings, or thofe prominences which cover the wings, but it does not even fhew the leaft leaſt ſigns or veſtiges of any ſuch part: whereas, on the contrary, in the other kinds of theſe Worms, the little ſheaths of the wings, fig. II. begin at that time to appear, and in the largeſt kind are as conſpicuous as poſſible, fig. III. reſembling a little flower, that increaſes by degrees, and is ready to break out of its cup.

CHAP. III.

Of the life of the Vermicle or Worm of the Ephemerus, when out of the egg; and of its food.

IT is very worthy of notice, that theſe Vermicles or Worms never, or but very rarely, are obſerved to ſwim at the bottom of the river, or even in the middle of the water. They can indeed ſwim very ſwiftly, and move and throw themſelves eaſily into ſerpentine windings in the water, whilſt their head is bent ſometimes up and ſometimes down; the reſt of the body advancing with the like twiſting convolution and ſerpentine motions. But, notwithſtanding they have this in their power, they are always found near the banks of rivers, and they live there in the moſt quiet parts. The more mud there is in the bottom, out of which they firſt riſe, the greater number of theſe Worms is uſually found. But you can very rarely catch them lying on the mud or adhering to it, but they live within the mud or clay itſelf in hollows made oblong and ſmooth. Theſe are bored, not obliquely or downwards, but always parallel to the horizon: therefore, Vander Kracht ſays right in Clutius, that theſe inſects live in ſeparate little cells.

As the Bees, therefore with wonderful and perhaps inimitable art form their habitations with wax; in like manner do the Worms of the Ephemerus make theſe hollow tubes, Tab. XIII. fig. v. *a*, or long holes for their reſidence, and bore them in the mud, in proportion to the bulk of their bodies. Hence, when theſe Worms are expelled out of their holes, ſo that they muſt creep on the plain or ſmooth bottom, which does not ſupport every part of their bodies, they immediately loſe their ability to go forward, though they are even ſurrounded with water, and are able to ſuſtain or bear themſelves up by ſwimming. This I have experienced, when I had drawn a great number of theſe Worms out of their holes, in order to diſſect them; they always fell on their backs, and, as if they were in a ſwoon, could not turn themſelves again: whereas, on the contrary, when they are in their little holes or burrows, they can creep very quickly backwards and forwards, and move themſelves every way as they have occaſion. I obſerve that it is common to all kinds of Worms which live in theſe kind of cells or holes to be able to move very quickly into their retreats, and when they are taken out of them, to faint as it were away. This I have obſerved in the Worms which live in hollow trees, and alſo in thoſe which are found in fruit, in the tubercles of the leaves, and in the galls or warts of plants. It is very worthy of obſervation, that the Coſſus or Worm of the great Beetle, whenever it is taken out of its houſe, covers its whole body with a web, by the help of which it forms a new hole for itſelf in the wood; for it could by no means pierce or make a hole, unleſs it were provided with ſome kind of ſtay or ſupport to lean againſt by preſſing its body in that part, and finding a due reſiſtance.

The bait or Worm of the Ephemerus is ſo weak when out of its hole or little tube, that if at any time it ceaſes to move, when ſwimming in the water, it immediately ſinks to the bottom in confuſion, and there lies on its back.

We are to remark further, that as ſoon as the Worms of the Ephemerus have iſſued out of their eggs, they prepare to build their cells or houſes, which we have obſerved are long and horizontal hollow tubes or caverns made in the clay or mud. But they make theſe tubes by degrees larger and larger, according to the ſize of the body, ſo that by this means the full grown Worms are always found in larger, Tab. XIII. fig. v. *a a*, the young ones in ſmaller tubes, *b b*.

The all-wiſe Creator has given them parts appropriated to this purpoſe; their two fore legs are formed, in ſome meaſure, as they are in the Moles and Mole Crickets. Theſe Worms have jaws likewiſe, which are provided with two teeth ſomewhat like the forceps or claws of crabs, and theſe ſerve very well to aſſiſt in making thoſe holes in the mud.

Hence you will immediately ſee them piercing or boring, when they are thrown into a little mud mixed with water. If you do not give them a ſufficient quantity of the mud, they will nevertheleſs continue to undermine what they have, at one time hiding their head, and at another their body, and afterwards their tail, attempting to prepare new cells.

The fiſhermen ſay, they are certain from experience that theſe Worms, when the water ſinks from the brink or edge of the river, always bore holes through the mud into a lower and deeper part, and that they likewiſe go to higher places, when the water riſes. This, I think, they are under a neceſſity of doing, ſince they have ſeveral air-pipes in their tracheæ, by the help of which they frequently draw new air, which is neceſſary to their life. This they could not do, if they were confined at too great a depth when the water rofe higher.

I have often obferved that when they were drawn out of their cells and put on the wet fand, they have chofe rather to creep out of the water, than go to the bottom under the fand. This might poffibly be owing to the want of mud, and the warmth of the water, which is probably injurious to them.

As to the food of thefe creatures, it is very difficultly difcovered, unlefs by the diffection of them, which taught me that they live on clay or mud only. Whenever you open them, you will always find mud both in the ftomach and in the fmall and great guts. Thefe Worms are therefore in this refpect like the Moth, which feeds on the fame fubftance of which it makes its habitation.

CHAP. IV.

How long the Vermicle or Worm of the Ephemerus is winged; why it is called the efca or bait; and how long it lives.

HAVING confidered the egg, the Worm, and the food of the Ephemerus, the next thing is to fee for what fpace of time this Worm is fed or nourifhed: and though it feems a thing impracticable to determine how long any creature which lives in the earth under water is in feeding, yet this problem may be folved by confidering the different bignefs of thofe Worms which I have beforementioned. Since the fmalleft kinds of them, when fed for one year, in which time the largeft kind prepares to fly, is three quarters of a thumb's breadth in length, and the middle fpecies is then only one half; it follows, that every Worm is feeding three years before it becomes fit to undergo its change, becaufe the largeft kind of Worms which begin this change, are two thumbs and a half long.

The largeft day Worms when fully nourifhed or fed, regularly go out of their cells into the water, and thence afterwards rife into the air, as I fhall explain hereafter. As every creature has its enemy, thefe have many; the fifh perfecute them immediately after they go into the water, in order to undergo their change; and when this is accomplifhed and they rife out of the water into the air, the birds immediately hunt after and prey on them. This has been obferved by the failors, fifhermen, and others, who live near the Rhine, fo that they learned from hence to ufe thofe little creatures as a bait to catch fifh. And hence it is that thefe Worms are called by the name of bait or bank-bait, near the village of Duerftede, Culenburg, and in other places. This has likewife been the reafon that thefe creatures, when they afterwards began to fly, have been called by the name of the flying bait. But this creature is called Haft at Rotterdam, Schoonhoven, and Dordrecht, the moft ancient city in Holland, as foon as it becomes capable of flying. Hence has arifen the common proverb among the Dutch, "Het iffer zoo dicht als haft," to indicate a very numerous multitude, becaufe thefe little creatures at the times of their change, fly fo thick together in fwarms, that thay can no more be counted than the falling flakes of fnow.

Thefe Worms afford a very good bait for fifhing at any time of the year, if the weather be favourable for that purpofe; for fince they live three years in the mud before they are changed in fo wonderful a manner, like Silk-worms, into flying creatures, they may be eafily taken out of the banks at any time of the year for the fportman's purpofe. But this cannot be conveniently done when the waters have rifen high, for it is then neceffary one fhould go naked into the water, which I have fometimes got done, that I might have an opportunity of inveftigating the nature and difpofition of thefe infects, and be able to examine anatomically the internal parts. When the fifhermen ufe this Worm, they fix the hook in the head, which is its hardeft and moft firm part. And as it is very long-lived, by the perpetual motion it makes in the water, it becomes a very proper bait to allure the fifh to fwallow the infidious hook.

How very durable the lives of thefe Worms are I could thus form a judgment: I have fometimes pierced one of them with a little needle, in order to dry and preferve it when dead, but it has been ftill living the day after, though it had been a whole night in a little veffel of urine, into which I had thrown it in order to kill it. But however tenacious they are of life, when they are taken out of their cells, and put into water mixed with clay they cannot live more than two days. Therefore, whoever defires to keep thefe Worms alive ought to put them in nothing elfe but moift fand or wet clay. By this means I have known the largeft live four days, and the fmaller eight. But when they are all covered with water, they cannot by any means continue alive, for they muft have air.

If any one defires to fend thefe Worms abroad, the beft method is to tie together fome tubes made of the largeft bull-rufhes, and to put the Worms into them; for otherwife they can fcarce be fent well, becaufe by running up and down at random, they hurt each other. By this method they may be likewife eafily carried to other rivers, as fifh are carried from one place to another.

CHAP. V.

Describes the external parts of the Esca or bait, its colour, and the difference in its manners and dispofition.

HAVING accurately examined the Worm of the Ephemerus, I obferve that it is divided into fourteen annular divifions; the firft conftitutes the head; the three fubfequent the thorax; and the other ten the belly, with the tail annexed.

In the head, Tab. XIII. fig. IV. *a*, the eyes are very confpicuous, being invefted with a uniform and fmooth coat, and covered on either fide with briftly hairs. When the Worm is on the point of changing its old skin, we obferve this fmooth coat to part or feparate by degrees from its eyes, and the eyes when the little creature begins to fly, appear reticular as they are in Flies. A little lower under the eyes are feen two tender horns *b b*, terminating in fharp points, and articulated or divided into joints. Under thefe are feen a pair of dentated forceps or jaws *c*, conftituting the creature's mouth. About the origin of thefe jaws, underneath, feveral more hairy and membranous little parts appear, which are fomewhat like thefe that we obferve in Crabs and Shrimps.

To the firft ring of the thorax are fixed the two fore legs *d*, the ftructure whereof, and the joints of which they confift, merit great notice. The ftructure is in fome meafure like that obferved in creatures that borrow under the earth. Hence the ftrongeft motion which thefe legs have is outward, by which they can the more conveniently pierce and remove the earth, like Moles in making their cells.

Every leg is compofed of four joints, and terminated by a fingle claw. The firft joint is affixed to the breaft; the next to this is fomewhat crooked, as is likewife the third, which confifts of a matter fomewhat more bony and horny than the others, and is armed with prominent brown red little points like teeth, and furrounded laterally with numerous hairs. The fourth joint is very fmall, and is armed with a fmall claw. The mufcles likewife, and their infertions may be feen very diftinctly here, by the help of which the bony joints are beautifully moved.

To the fecond divifion of the thorax, which is the third ring of the body, and properly conftitutes the loins, and is covered both above and below with a fhield of a horny little bone, is annexed a fecond pair of legs, Tab. XIII. fig. IV. *d*, which confifts of five joints and one claw; and are here and there furnifhed alfo with hairs. Somewhat behind thefe, the follicles or little fheaths *e*, wherein the firft pair of wings are concealed, are feen on each fide. Thefe fheaths are here and there interwoven with air veffels, which appear on their external furface, like common little veins or nerves. When the Worm is juft going to caft its skin, the internal or under wings are folded in a wonderful and elegant manner, and appear through their external coats or follicles.

There apperrs on the third ring of the thorax, which is the fourth of the body, the infertion of a fecond pair of wings, which are much lefs than the firft pair, and are wholly covered by them. This firft pair likewife partly covers the hindermoft or laft pair of legs, which confift like the others of five joints and one claw, and are adorned with numerous hairs.

The firft ring of the abdomen, or the fifth annular incifion of the body, is all even and fmooth, nor is it joined to the legs, the wings, or any other part. To the fix following rings are affixed very beautiful branchiæ or gills *f f*, perpetually fluttering, and beating up and down with a tremulous motion. By the help of thefe Clutius erroneoufly thinks the Worm fwims; but thefe parts are undoubtedly the branchiæ or gills of the creature. In Lobfters, Crabs, and Cuttle-fifh, which approach in many refpects to the ftructure of infects, we conftantly find thefe little parts framed and fituated in the fame manner, with this difference only, that in Crabs and Lobfters they are enclofed in a hard fhield, wherewith the back is covered, but in thefe as well as in the Cuttle-fifh, they are fituated higher on the body than in the Ephemerus. In the figure of this Worm given by Crachtius, twelve gills are expreffed on each fide. This error feems to have arifen from a wrong view, fince there are only fix on each fide, the whole only make twelve.

The eighth and ninth divifions of the belly, which conftitute the twelfth and thirteenth rings of the body, are all even and fmooth. Thefe are fucceeded by the tenth or laft, that is, the fourteenth divifion of the body. This is adorned with three hairy and briftly tails, Tab. XIII. fig. IV. *g*, to which are alfo added two crooked appendages, which are not fo remarkable in the females; but in the males they are likewife accompanied with fome other little appendages underneath.

As to the colour of thefe Worms, the fmalleft appear of a pale blue with a tinge of green. This, however, cannot be properly faid to belong to the creature itfelf, but is rather owing to the vifcera which are feen through. The eyes of all thefe Worms are of a blackifh brown colour, and the back is fpeckled with pale brown fpots, which increafe by degrees with its age. The mouth is palifh, and is furnifhed with redifh brown teeth; of this colour are alfo the

the forceps or jaws which are beneath them, having two teeth and conftituting part of the mouth. The horny parts and the claws of the legs are likewife of a reddifh brown.

The exuberant wings infenfibly change their pale colour into a yellowifh one, which, in procefs of time becomes a bright blue, and at length a brown black. The whole body of the creature is by little and little ftained with a pale yellow colour, and the blackifh fpots in the back, where it conftitutes the upper part of the belly, are changed by degrees into a deeper colour.

The difference between thefe creatures with refpect to their fex is another point very worthy of notice. For the eyes, Tab. XIII. fig. IV. *a*, of the male, are twice as large as thofe of the female, fig. III. but the body of the male is commonly much lefs than that of the female, which is the cafe in infects in general, as far as I have obferved; and it feems to be ordered very prudently fo by nature, or more properly, by the very wife Creator, in order to give the due room to a large number of eggs. The male in this fpecies has the tail very long, and befides he has three or four other appendages, placed partly on the fides, partly under them, which can fcarce be diftinguifhed in the females. The male that I exhibit in fig. IV. of Tab. XIII. is the largeft of all I have feen, though much larger females may be found.

As to the difpofition and manner of this infect, I can fay little from my own obfervation: but one thing I may venture to affirm, that among all the fpecies of infects, I never faw any one more mild, gentle, or innocent. For in whatever manner it is treated, it is always calm and peaceful, and when left to itfelf, it immediately goes to work, and begins to dig a cell for its habitation. I have obferved indeed in the fmalleft fpecies, that when rudely handled, it bends its head towards its breaft, and makes itfelf fomewhat ftiffer. Of all the actions of this creature none is more admirable than the agitation of the branchiæ or gills, Tab. XIII. fig. IV. which adhere to either fide of its body, for thefe are fo orderly, diftinctly, and continually fhook and vibrated, that the mind, when intent on thefe incomprehenfible movements, is filled with aftonifhment.

CHAP. VI.

The anatomy of the internal parts of the Ephemerus.

HAVING briefly defcribed the egg, Worm, food, age, external parts and difpofition, fo far as I obferved, of our little infect, what fhould naturally come next into confideration would be to explain its change. But as this is performed fo haftily, that it confifts almoft only in the cafting of two coats or skins, and the difplaying or unfolding of fome limbs and parts before covered, in order to underftand the difference between the fwimming Worm and this flying infect the more diftinctly, I think it better to defcribe its internal parts firft; and the rather, becaufe all thefe parts under both forms of this creature may be in this account taken notice of.

Though in defcribing the internal parts of the Efca or Worm of the Ephemerus, I fhall enter upon them in a method not yet obferved by any perfon that I know of; yet, according to the example of Clutius, I fhall not complain of the fcarcity of books, treating of this fubject, nature herfelf being the beft interpreter of all her works: books are to be admitted no further than as they exprefs the truth of what fhe reprefents to our fenfes. I am therefore in pain for thofe, who, relying on the experiments related by others, frame innumerable fictions, and therewith deceive their readers with themfelves. It cannot be poffible that any perfon relying on his own underftanding and judgment, fhould, in fuch a variety of experiments, follow the ftraight path of truth, and with an unprejudiced and candid judgment pafs a juft fentence on the obfervations of others, efpecially fince we obferve that the moft certain experiments are obftinately rejected by many, unlefs they correfpond with their own opinions or prejudices. I fhall build only on what I have feen, though I may in this perhaps be blamed; for that not having had a fufficient number of the Worms, I have not been able to bring their diffection to the utmoft perfection, fo that in this refpect I cannot every where fatisfy my own inquiries. But I have long fince learned, that the works of God are as inexhauftible and incomprehenfible as his own perfect nature; fo that thefe things ought not to be contemplated by us for any other purpofe, than that we fhould be humbled by a due confcioufnefs of our ignorance, and be obliged to adore their Creator, and love him truly.

In order to make the obfervations I have to offer as clear as poffible, I fhall at the fame time declare the method, which I made ufe of in the year 1670, to determine the true diffection of the feveral parts; for it is by no means my intention to deceive either myfelf or others. Before I proceed to the defcription of the internal parts, I fhall, in order to affift the memory, briefly enumerate what parts are obfervable outwardly in the Worm of the Ephemerus, as alfo what inward parts I found in the male, and what in the female.

The external parts of the Worm are the head, fkull, horns, eyes, teeth, mouth and tongue, together with their hairy membranes, which are like thofe in the Crab kind. The breaft, legs, claws, wings, belly, and what appertains

pertains to it; the twelve upper branchiæ or gills, the ten lower oars that ſerve the creature for ſwimming, the tails with their appendages, and laſtly, the apertures of the pulmonary tubes under the breaſt.

The inward parts of the male are, beſides the blood and membranes, muſcles and fat, the ſtomach and inteſtines, the pulmonary tubes, the heart, the ſpinal marrow, and the ſpermatic veſſels.

In the female I find all the parts juſt recited, with only this difference, that inſtead of ſpermatic veſſels an ovary is here ſeen, ſurrounded with ſmall membranes, which are interwoven with very many pulmonary tubes.

As I have not yet accurately examined the internal parts of the head and eyes, for want of a ſufficient number of Worms and Flies, I ſhall not ſay much concerning them, nor of the parts of the thorax, the latter being for the moſt part filled with the muſcles of the legs and wings.

If the male Worm of the Ephemerus, which it is eaſy to diſtinguiſh from the bigneſs of its eyes, be firſt laid on its back on a ſmall piece of a fir board, and then faſtened with the ſmalleſt needles that can be had on black paper or a ſmall piece of linen, we immediately ſee a thin and watry humour diſtilling out of the wounds in the ſkin, which is the real blood of this inſect. And yet it is not red, as is the caſe in Earth-worms, the blood of which, as well as that of quadrupedes, is tinged with that colour. I don't know a more proper inſtrument to open the ſkin than a fine and ſmall pair of ſciſſors, for little lancets, though never ſo ſharp, are not fit for this purpoſe, becauſe they always pull and tear the parts aſunder, and eſpecially if the membranes be not equally hard.

When the ſkin is after this gently and deliberately ſeparated with a fine ſharp-pointed pen-knife from the parts underneath, an interior very thin and membranous ſkin immediately appears. If this be afterwards cautiouſly removed, the muſcles of the belly preſent themſelves to view, as well thoſe which extend from one diviſion to another, with ſtraight fibres of the body, as thoſe which are protended obliquely and acroſs: other muſcles are alſo ſeen, which ſerve to move the branchiæ or gills. The coat or other ſkin is likewiſe fibrous, and ſeems to be joined to the muſcles before deſcribed.

After the muſcles appears a very fine and delicate membrane affixed to them, which I take to be the peritonæum. About and under this appears a quantity of fat, conſiſting of ſmall, fine, and white veſicles, which contain a real fat in the form of fluid oyl. Whoever views theſe veſicles without a microſcope, may naturally take them for the fat itſelf, whereas they are only thin and very tender bags containing it, as is the caſe in man and other animals. This will be very plain, if theſe pinguiferous bags, which are of equal bigneſs, be viewed with a microſcope. The younger the creatures are, the more conſpicuouſly they exhibit this fat, ſince it then lies here and there diſperſed on the membranes, nor is it heaped together ſo thick as in the older ones.

After obſerving theſe, we come to the ſtomach, Tab. XV. fig. v. and to the inteſtines which are continued from it. Here is preſented to view the œſophagus, or otherwiſe the tube of the upper orifice of the ſtomach, which deſcends like a fine filament from the mouth or jaws through the back and thorax, and enters and is connected with the upper part of the ſtomach. Where this little tube is connected with the ſtomach, it becomes narrower and cloſer *a*, as may be ſeen about the lower part of the ſtomach, or towards its lower orifice *b*.

Though the ſtomach *c* conſiſts of divers parts, yet it ſeems throughout to be formed of a thin and tender membrane, corrugated on the inſide, and full of reticulated or net-like folds or plaits. On the outſide it exhibits a ſmooth ſurface, and is expanded regularly, eſpecially when it is ſwollen or filled with food, or if it be artificially diſtended with air, by the help of a ſmall glaſs tube. No veins or arteries are ſeen in it, for the blood of theſe inſects is of a watry colour, and therefore does not diſtinguiſh the veſſels containing it from the other parts; this is the reaſon that theſe creatures were called exanguious or without blood.

It is however obſerved, that the ſtomach *c* is provided with many tubes which reſemble blood-veſſels. But if they be well examined with a microſcope, it appears they are branches of the pulmonary pipes, Tab. XIV. fig. I. *a a*, for they give little air canals, not only to the ſtomach but to all the external as well as internal parts of the body. Hence, even the legs and their claws have air tubes. The inteſtines, Tab. XV. fig. v. joined to the under part of the ſtomach, appear to be threefold in regard to their form and ſtructure: there appear, 1ſt, the crooked or ſmall gut *d d*; then 2d, the colon *e*; and laſt, the rectum *f*. Within the ſmall gut, ſomewhat further towards the hinder parts, are obſerved ſome lunated wrinkles, not unlike thoſe little vales of the ſmall guts in the human ſpecies, which the anatomiſts call annulares. A little below where the colon *e*, riſes out of the former, are ſeen ſeveral oblong furrows, which are very fine in the living creature, and reſemble ſo many long muſcular villi or hairy parts extended in the cavity of the inteſtine, correſponding in ſome meaſure with the echinus, which is a natural part of the ſtomach of quadrupedes: then the rectum follows this, and is folded very elegantly, until it terminates at the external parts of the body with a pretty large orifice, through which the fœces are diſcharged.

The ſtomach *c* is ſituated between the fourth and fifth annular diviſions of the body, and there, together with the ſmall gut, takes up the whole foremoſt region of the belly, that is, the 6, 7, 8, 9, 10, and 11th inciſions. But the

the other three divifions, namely, the 12, 13, and 14th, contains the inteftinum rectum et craffum, or the thick and ftraight gut. As the ftomach has a great number of fmall air-tubes, fo the inteftines have alfo the fame, but moft efpecially the rectum, which has vaft numbers of them, where its two mufcles, Tab. XV. fig. I. *i i*, which force out the excrements are fituated.

As the food of this Worm is mud or clay, the ftomach and inteftines are ufually found filled with it. This mud is found almoft always to fhew itfelf both through the ftomach and inteftines, and indeed through the whole body, but more particularly fo in the back. And hence, as the body is fo tranfparent, it follows, that the Worm does not appear to have always the fame colour, fince the mud is fometimes paler, fometimes greener, and fometimes more flefh-coloured, as it is more or lefs digefted or changed in the ftomach and bowels.

As the time approaches when the Worm is to undergo its final change, and put on the form of a flying infect, no more mud is found in its inteftines. The fame likewife happens in the Coffi or Worms of Beetles, and in Bee-Worms and Silk-Worms, as alfo in other infects, for they all at that time become clear as chryftal. Some infects are all their life-time tranfparent, fo that their veffels, the vifcera, and their motions may be at all times feen and diftinguifhed in the body.

Of the inward parts of the Ephemerus, the moft worthy of notice are the pulmonary tube, and the afpera arteria tracheæ or windpipe, Tab. XIV. fig. I. *a a*, as it is called in birds and quadrupedes, and in the human fpecies. This tracheæ does not proceed in the prefent infect from a fimple trunk, as in man or other animals, but confifts of two principal trunks, which are placed on each fide of the body running in a ferpentine manner, nor are they diftributed in the breaft only as in us, but throughout the head, belly, legs and wings, fo that by their means the ftomach and inteftines, together with the mufcles and nerves, are all fupplied with air. As this appears to us a very wonderful thing, becaufe we do not underftand the reafon of it, it moft evidently teaches us how devoutly and religioufly we ought to adore God in all his prodigious works, which are equally inexhauftible and impenetrable.

The pulmonary tubes * in this infect, as well as in the others that I have examined, confift of innumerable little rigid and curled parts, which are artificially joined together like twifted or fpiral rings, and are fo clofely linked to each other by the help of their tender and delicate invefting membranes, that they can eafily retain the air, and convey it to all parts of the body.

When the Worm changes its skin, I fhould imagine that thefe pulmonary pipes likewife caft their covering, though I have never hitherto been able to fee it; for at the time when I began thefe experiments no fuch thing appeared to me. The change or cafting of the skin of thefe pipes is fo remarkable in Silk-Worms, that it amazes the underftanding; for in the very fhort fpace of time wherein that creature cafts its skin, fome hundreds of thefe pulmonary pipes in the infide of its body, caft alfo their tender little skins, which are all compounded of fuch twifted rings.

The colour of thefe pulmonary tubes or pipes is like that of mother-of-pearl, but fomewhat inclining to gray; but the more frequently the skin is changed, it becomes by degrees of a clearer and more tranfparent whitenefs. They are therefore much whiter in the flying creatures than in the Worms which precede them. They are diftributed through the whole body, in order to convey the air, which they carry as well to the internal as external parts of the infect. Hence thefe two moft confiderable and remarkable tracheæ, Tab. XIV. fig. I. *a a*, which are placed in the Worm on each fide of the body, diftribute their ramifications and branching air-pipes all over it; that is, in the head towards the nerves and brain *b b*; in the thorax *c c* to the mufcles of the legs and wings; in the abdomen *d d d d* to the obliquely afcending and ftraight mufcles, as alfo to the fpinal marrow *e e e*; and to the fmall guts or feminal veficles *f f f* of the male; to the hairy branchiæ or gills *g g*; to the ftomach, Tab. XV. fig. V. *c*, and the inteftines, Tab. XIV. fig. I. *h*; to the fkin *i i i*; to the coat of the wings *k k*; to the ovary, Tab. XV. fig. I. *l l*: in the female alfo to the coat that invefts the ovary *m m*; to the eggs themfelves. fig. VII. *n*, as is feen when they are taken out of the body, and even to the heart itfelf. Fig. IV. *o o. t t.*

I have found it a difficult matter to difcover the external aperture of thefe pulmonary pipes, fince they do not open into the mouth or throat, as in other creatures. For which reafon the nearer they approach the head, the fmaller they become, when it would be natural to fuppofe they would become larger and more capacious. At length, after repeated inveftigations, I perfwade myfelf that I obferved that the little apertures or entrances of thefe pipes opened underneath in the fide of the breaft; almoft in the fame manner as I afterwards difcovered them alfo in Locufts, in which laft mentioned infect thefe apertures may be eafily feen. But as the Ephemerus lives in water and mud, therefore its tracheæ muft be opened by narrower orifices, on which account it is more difficult to difcover them.

From thefe experiments it appears moft evident, why the Worms of the Ephemerus or Day-Fly, when the water of the river increafes, rife

* The doctrine of thefe pulmonary tubes in infects has been confirmed by all fucceeding obfervations: the latter authors only have changed the names of thefe veffels, and their openings on the furface of the body. They call the tubes tracheæ, and the apertures on the furface of the body, which this author terms puncta refpiratoria, they call ftigmata. This laft term, though more modern, is exceptionable; for ftigmata is ufed in botany to exprefs the heads of the ftyles in flowers, and pure philofophy condemns this equivocal ufe of terms.

rise likewise higher, and go to other cells, for they very frequently want fresh air to breathe. And for the same reason, when the water is lower, they must be likewise found to descend deeper; for they would then become too dry, and their cells or habitations would be dried and shut up.

The pulmonary pipes hitherto described cannot, in any insect, be examined better than in the Worms, when they have been dead some days, as their viscera are then growing black; for then they exhibit a very beautiful appearance to the eyes, because they are of the colour of mother of pearl, or silver when cleaned by boiling; also, as they consist of a somewhat hard and firm substance, so that they do not soon putrefy: hence they also retain at that time their form and roundness.

If the breast and belly of these worms be viewed with a microscope, the whole abdomen is seen to be interwoven with white silver-coloured vessels. In order to discover whether there be really any air in these vessels, they must be put into a little drop of water, and pressed with the point of a needle, for thus the enclosed air will immediately shew itself. When these insects are dissected under water, and some of the pulmonary pipes are cut off with a fine pair of scissors, they immediately rise to the surface of the water; the same thing may be seen about their broken ramifications, the extremities of which are then carried upwards. In a Worm that has been dried, having been divided in the middle, these air-pipes are most easily discovered, because they always in that case remain open from the force of their curled rings, though all the other parts grow perfectly hardened.

Amongst the many things which may be observed concerning these pulmonary tubes, it is particularly worthy of notice that so great a number of them are distributed towards the branchiæ, Tab. XIV. fig. I, or gills, so that three principal branches *ppp* of the air-vessels may be seen in those which I have represented as cut off: the middle one of these branches is alway blackish *qq*, except in the centre of it, which is whitish and transparent; the other two run on either side of the middle black one, and distribute a large number of silver-coloured vessels *ggg* through the branchiæ or gills. These vessels are not well distinguished by their colour, because the six branchiæ or gills, Tab. XIII. fig. IV. *ff*, through which they are conveyed from each side of the body, are white and very transparent. Under these, on each side, are observed five rowing fins, Tab. XIV. fig. I. *rrrr*, of a yellow colour, by the help of which the Worm swims.

I made during my dissections some further observations on those branchiæ and their vessels, but as I do not know where the papers are, the observations have also entirely slipped out of my memory. Hence I am ignorant what use that feathered little part *ss* is of, which is seen under the first as yet entire pair, and whether it be likewise found about the other branchiæ or gills. Neither do I know the proper communication between these branchiæ and the air-pipes, Tab. XV. fig. IV. *oo*, between the latter and the heart *tt*. I cannot therefore say any thing more with certainty concerning them than what may be gathered from the figure. I omitted, to prevent confusion, delineating in this all the air-pipes which are about the heart, having exhibited some of them only entire, and others cut off or broken *vv*.

Indeed, in my figures I have not always observed the proportional magnitude of the parts, since I looked upon that as a work of great labour and little use, and therefore I have not scrupled sometimes to delineate one part larger than another. Besides, I never intended to publish these experiments, without being first revised; and this I have afterwards thought the more necessary, because from that time I acquired a greater knowledge of the parts of these insects, and became more capable of ascertaining their anatomy. I hope the benevolent reader will kindly pardon the imperfections of this work, which I must confess are innumerable; for what man is able to describe, even with the uninterrupted labour of many years, all the miracles that are to be met with in this little insect.

The heart, Tab. XV. fig. IV. *tt*, is found to be placed in the upper part of the body in the back, as it is in Silk Worms, Bee Worms, Cossi, or Worms of Beetles, Caterpillars, and other insects of that nature. It is somewhat protuberant *xxxx* in several places, and it is so in Silk Worms also, as has been observed by the diligent Malpighius. But this author does not seem to me, as far as I can learn from my own experiments, to have fairly from this drawn his conclusion that this insect has more hearts than one. I have discovered the motion of the heart but very inaccurately in the Ephemerus, and only in that part of it which I here represent in the figure; but I have entirely forgot, against which of the annular sections it was placed in the back.

The spinal marrow, Tab. XIV. fig. I. *yyy*, is wonderful and very worthy of notice in this, as it is in all other insects that I have dissected; it consists as of eleven knotty tubercles, somewhat long and oval. The first of these knotty little parts serves instead of a brain, out of which * * the optic nerves may be very distinctly seen to arise and spread themselves. In the same manner I have observed, that the rest of the nerves issue from the ten subsequent little knots; but these that arise from the lower knots, are not so numerous as those from the upper. The spinal marrow is moreover found to be here and there beautifully strengthened with ligaments *zz*, which are composed partly of a strong horny substance, and partly of tendinous wreaths or fasciæ. This is the case in the breast in particular, for there the spinal marrow sends out a great many nerves to the muscles, *αα*, *ββ*, which move the legs and wings: the

same

ſame thing happens about the muſcles of the branchiæ, Tab. XIV. fig. I. *c c*, and rowing fins.

From each little knot, Tab. XIV. fig. I. *e e*, of the ſpinal marrow, there conſtantly iſſue two ſtronger nerves, which unite and become more ſwollen when they approach the ſubſequent nerve; for which reaſon the ſpinal marrow appears every where divided and open. But while it is in its ſtate of nature contained within the body, that gaping does not appear; becauſe the nerves are there only ſimply contiguous to each other, and do not therefore appear to be far diſtant from each other; as I have ſhewn in the ſixth figure, Tab. XV. in which the ſpinal marrow, as it is naturally contained in the body, and the fourteen annular inciſions of the creature wherein the marrow lies are delineated.

If any one has a mind to view the ſpinal marrow, without hurting or injuring the creature, let him fill the body with air blown in through the hinder part: for thus the marrow will be by the force of the ſwollen inteſtines ſo ſtrongly preſſed againſt the tranſparent skin, that one may conveniently view its natural ſituation and form, even with the naked eye, as well as with a microſcope. But this contrivance can be uſed in the males only.

The ſpinal marrow, as well as the other parts of the creature, has its air-pipes, and indeed a great number of them; ſo that the brain and nerves are continually as it were ventilated with injected air. I do not doubt but the marrow has veins and arteries, though I never ſaw them; for in Silk-worms I have clearly ſeen various ſmall veſſels ſpring from, and approaching to the heart, which I have even filled with a coloured liquid. But whether they were veins or arteries, I cannot yet affirm.

The ſpermatic veſſels, Tab. XIV. fig. I. or genital organs, are as conſpicuous in the male of theſe Worms, the day before it changes its skin, as in the male Ephemerus, or the Fly thence produced after changing its coat. Theſe ſpermatic veſſels are found to be placed on each ſide of the ſtomach and inteſtines, and appear like the ſmall guts in Fiſh. There are, however, ſome bendings and windings in them, like the ſeminal veſicles in the human ſpecies and they are found in manner of tubes: therefore, in this reſpect, they are alſo analogous to the ſpermatic veſſels of ſome quadrupedes, as Moles, Hedge-hogs, and the like. They are in theſe, Worms of an oblong figure *f f f f f*, and are extended all over the belly, as is evident from the annexed figure, wherein I exhibit one of them taken out of the body, and the other ſomewhat larger than nature in it. They contain in their cavities a very white humour like milk, which is the ſperm. The ſeminal veſſels themſelves are likewiſe perfectly white, and they are of a thin and membranous texture, and have many air-tubes all over them both within and without.

In the lower rings of the abdomen appear two other little parts *d d*, which likewiſe in my opinion belong to the ſpermatic veſſels; for they ſeem to have a common paſſage with them and with the inteſtines, Tab. XIV. fig. I. ☊; which however I could not at that time ſo accurately diſcover, being engaged in other parts of this diſſection. And indeed we muſt diſſect a great number of theſe inſects, if we would endeavour to diſcover the whole fabrick, ſearching in another what we could not examine to our wiſhes in the former; and even with this caution we cannot always execute our deſign perfectly.

The ovary is double in the females, Tab. XV. fig. III. and it is placed in the ſame manner as the ovary in Fiſhes. But if the skin of the abdomen be opened a little way with a fine and ſharp-pointed pair of ſciſſors, that congeries or heap of eggs, fig. I. *l l*, ſituated on each ſide of the ſoft part of the belly, comes in ſight. Between theſe, in the middle, the ſtomach and inteſtines *f f* are ſomewhat obſcurely ſeen through the other parts, and the latter are themſelves ſtrongly connected with the membranes *m m* of the ovary. The ſtomach and little inteſtines appear the more plainly, the more they are filled with mud, which is the food of the Ephemerus; and for this very reaſon the eggs may be ſeen alſo more beautifully; for their whiteneſs, ſhewing itſelf brighter on account of the diverſity of colours, makes them the more diſcernable.

The double ovary of the Ephemerus has innumerable air-pipes, which are tied to a ſmall membrane that ſurrounds the ovary; and by means of the latter they are conveyed to the little eggs hidden on the inſide. But if this membrane be removed with the point of a fine needle, and ſome part thereof put together with the eggs into a ſpoonful of water, the eggs immediately ſeparate from each other, and there remains a fine, delicate and tender bundle of minute veſſels, fig. VII. *g*, which I take to be moſtly air-pipes, being like fine filaments, and conſpicuous by their colour like mother of pearl.

The eggs are likewiſe ſo extremely ſmall, fig. II, that they can ſcarce be ſeen. It is therefore neceſſary to view them with a good microſcope, and to put them on black or blue paper, which contributes to their being the better diſtinguiſhed.

The eggs are of a plain round and oblong figure, and are ſurrounded with a tolerable firm membrane, which appears cloudy under the microſcope, and they are of a white colour, like the inner skin of an egg-ſhell. Since therefore the eggs of the Ephemerus are ſo ſmall and delicate, the reaſon is evident, why the Worms iſſuing from them muſt be increaſing three years before they come to perfection, and are able to commence their change.

CHAP.

CHAP. VII.

The ſigns by which to diſcover, whether the Ephemerus is to fly in a ſhort time; as alſo what may prevent it, and to what claſs or order of natural changes it belongs.

THE general preceding ſigns of the approaching change of the Worms of the Ephemeri into flies, are, in regard to the weather, a warm and dry ſpring; a mild winter, without much rain or ſnow; and a gently running water. The peculiar ſigns whereby to know that theſe Worms will change into Flies in a ſhort time, conſiſts in a protuberance of the wings on the back; for about that time the ſmooth and depreſſed form of the upper part of the body is changed into a more ſwollen and rounder ſhape; that is, that glutinous fluid which is at other times found in the coats that ſurround and defend the wings, becomes thicker and more clammy: hence it is, that the wings are at that time in ſome degree viſible through their external ſkin, Tab. XIII. fig. VII. *aa*.

Theſe ſigns are more certain when the colour of the wings within is obſerved to change from a yellowiſh and paliſh to a grayiſh hue. There is alſo a ſtill greater certainty, if, after the external coat of the wings is taken off from the inſect's body, the wings can be expanded without hurting them: as appears in Tab. XIV. fig. I. under the letters εεε; where I exhibit the magnified wing, and as it is artfully folded by nature.

Another ſign likewiſe preſents itſelf in the diſſection of theſe inſects: that is, when we find the genital parts and eggs have acquired their full bigneſs, their due hardneſs, and true figure. We may then take the whole creature out of its ſkin, by art, and by this contrivance change it into the form of a flying Ephemerus ourſelves, not waiting the moment of nature.

All the viſcera of this inſect are then cleared from their contents, which were a kind of dirt; nor is there any thing in the ſtomach and inteſtines but tranſparent and depurated humours, which appear the more dusky, foul, and coloured, the further the time of the change is diſtant; ſo that they are ſometimes yellowiſh, and ſometimes dusky and red. At other times a little mud is found in the extremity of the thick and ſtraight gut and colon; but, on the contrary, theſe inſects are all over clear and tranſparent, when the time of their change is juſt at hand.

The following accidents keep back the changes of the Ephemerus, deſtroy its life, or prevent its growth; inſomuch that ſo great numbers of theſe inſects are not produced as might be expected; nor do they come to ſuch maturity. An inclement, boiſterous, tempeſtuous, long, rainy and ſnowy winter, deſtroys numbers. By this the cells inhabited by the Worms are deſtroyed, being worn out, or ſhut up and covered with ſand. Too much drought or dry weather afterwards occaſions the ſame deſtruction; for they are then compelled to quit their little cells, and make themſelves new ones from the decreaſe of the water; and many are loſt in this operation. From what has been ſaid, we may eaſily ſee what favours and what injures the Ephemerus; what leſſens it troubles and misfortunes, and what increaſes and multiplies them.

What I have a little before advanced concerning the maturity of the wings, ſhews to which of the orders of the four natural tranſmutations this inſect belongs; that is, to the ſecond claſs or order. For all the inſects of this order are changed in the ſame manner as the Ephemerus.

Indeed, Clutius feigns that the Worm of the Ephemerus is changed into a Nymph of the third order, and on this loſes all its motion, like the Nymphs of Silk-worms; he even exhibits a figure of that Nymph, though there is no ſuch thing in all nature. Hence it is evident how much they are deceived who neglect the truth of experiments, and give credit to their own reaſonings, or to the falſe relations of others.

CHAP. VIII.

How and in what a wonderful manner the Worm is transformed into an Ephemerus.

WHEN the time of the change of the Worm of the Ephemerus is approaching, and the wings, Tab XIII. fig. VII. *aa*, hidden in the caſes or huſks, have acquired their due ſtrength and form, and that it is no longer in the power of the Worm to delay its change; thoſe which have their parts thus diſpoſed and prepared, march out of their habitations into the water. This usually happens in the evening between six of the clock and half an hour after. This I observed on the thirteenth of the month of June, in the year 1671, pursuing the change of the Worms of the Ephemerus.

The other Worms, which are not as yet come to this state of growth, remain in their cells. Those which have crept into the water move forward, and make all the haste they can from the bottom to the surface; which, when some more swiftly and others more slowly are arrived at, each of them, fig. VII. is changed into a winged insect, fig. VI. and VIII. But this change or casting of the skin is so suddenly performed, that even the most attentive person cannot otherwise judge, than that the Worm breaks or bursts its way and swiftly flies out of the middle of the water.

Every insect that I have hitherto observed has a certain and determined time appointed for it by the omnipotent God, to expand its wings and dry them, that they may become smooth and polished, before they are able to prepare themselves for flight. But the Ephemerus, on the contrary, is almost at one and the same point of time a reptile and a flying creature. Wherever one sees at this time a little water bubble up, if we casts our eyes on the surface, there is immediately a winged insect observed to issue out of the middle of the water. Argus would want eyes, if he should attempt to trace these miracles of the adorable Creator of the universe.

If any one goes into a boat and fixes in a situation directly against the descending stream of a river, then he may very well see these insects emerging or rising up, and casting their skin. For, though you should as soon as possible catch the Worm still floating on the water, yet you can scarce look at it before it is winged and flying. This may however be prevented, and the Worm taken out of the river before the change is performed, if it be struck a little, or bruised on the breast; which is necessary to be done, if one would view the creature at this period not yet changed, but covered with its skin.

It is difficult to say what is the reason that these wings are so swiftly expanded, and yet have neither muscles nor joints in them, but only artificially plaited and folded; nay, they must again change their skin the moment after. This difficulty surely is very worthy to be solved. I indeed thought it necessary that these wings should be provided with muscles and joints in the substance of them, as we have observed in many other insects; for the latter can by the help of such joints and muscles very artificially contract their wings into a narrow compass, and again quickly unfold or display them. This holds, amongst the rest, in Ear-wigs, which hide or put up very long wings in a small sheath, which folds and covers them so neatly, that they seem to be quite destitute of wings. But though the Ear-wigs can by the power of muscles and joints, which they have in the middle of their wings, closely fold these wings in the same manner as in the Ephemerus, which has not yet gone through its change, and again quickly expand them; and though I thought the Ephemerus was in need of the like assistance, yet the supreme Architect has not been pleased to make use of the same structure; and it appears that even this structure was not necessary.

If the trials that I have hitherto made can throw any light on this instantaneous expansion of the wings, it must consist in this; that I think the water, which is warmer on the surface than in the bottom of the river, flowing all over and penetrating into the wings, contributes very much to their expansion. For by the assistance of the water, the blood which is then driven out of the heart into the wings, in order to promote this needful expansion, may be impelled with greater force, in the same manner as we see the blood is, by the help of hot water, drawn more plentifully into the feet, and those parts are more distended when any one is blooded in the foot. Thus, because the blood and all the humours in this insect, when it gets into the water swims about and is employed in changing its skin, are violently moved; hence the surrounding water may be of great service to impel the humours contained in the wings, so that they may be more expanded. Wherefore we likewise observe that in the wings of insects, if wounded at that time, there follows a mortal hemorrhage, or if the creature survives, the wings are never afterwards displayed. To the more ready expansion of these wings, the impelled air likewise probably contributes very much, because it is conveyed thither through the numerous pulmonary tubes, and may serve for giving strength and firmness to the pulmonary pipes, and for expelling the humour from thence. If you cut off the wings of the Worm of the Ephemerus when it is very near its change, and throw them into a bason of water, you will immediately see them expanding by force of the water flowing round them, and at length extending themselves into their natural, smooth, and even surface, so that they would serve the creature to fly, if they were dry and strong enough. I have often made this experiment on the wings of this insect, and by that means have in some measure learned how they are expanded. When I have put them in the water, in the manner beforementioned, I have observed that their larger folds were first opened, Tab. XIV. fig. I. *e e e*, and then, by degrees, the wings were stretched out in length, Tab. XIII. fig. IX. Afterwards the longitudinal plaits of the wings were expanded, fig. X. until at length the whole wings, fig. XI. were entirely shewn open. This may be seen in the insect itself, fig. VIII. which I have delineated from the life; but the figures of the wings beforementioned are drawn with the help of a microscope. So long as the wings con-

continue in their plaits and folds, they are of a dark gray colour; but this by degrees becomes more faint when they are expanded.

When the Ephemerus has, fig. VI. and VIII. taken its firſt flight, it ſeeks out with all ſpeed for ſome place where it may quietly reſt; and having found ſuch a one, it caſts off, fig. XII. and XIII. a very thin and tender skin from its whole body, that is, from its head, breaſt, belly and wings. But before I treat of this other change of the skin, I muſt obſerve that it is always made on dry land, whereas the former is conſtantly performed in the water. And the firſt change is likewiſe much more admirable and worthy of obſervation than the ſecond. When the Ephemerus firſt caſt its skin or outward coat on the ſurface of the water, it at that time entirely loſes its former ſhape; but this is not the caſe in the ſecond change.

Therefore under the firſt of theſe changes, in which the skin of the Worm opening on the head and back, ſuddenly is ſeparated from the body, until the Fly ſpeedily and quickly makes its way from thence, ſome very conſiderable parts are loſt, that is, fig. IV. *ff*, all the branchiæ or gills on each ſide, together with the ten rowing fins under them. Nay, when theſe branchiæ are ſeparated, they do not leave even their hairs upon the body, but all vaniſh away ſo entirely, that only ſome ſmall veſtiges or points remain of them, which form a little margin or border on the ſides of the belly. The Ephemerus loſes alſo its teeth or forceps *c*, and the former ſhape *d d* of its legs, and the caſes of its wings *e*, and tails *g*, and other parts. Hence the Ephemerus having gone through this change of its skin, is become as it were another creature. fig. VI. and VIII.

But as it is very difficult, perhaps impoſſible to obſerve all theſe things in the very ſhort ſpace of time in which the skin is caſting, any perſon may do this at his leiſure, if he gently and dextrouſly ſtrips the Worm, that is to change immediately, of its skin. For then the parting branchiæ or gills, which adhere to the exuviæ or caſt skin of the Worm, are ſeen very plainly: there likewiſe appear thoſe prominent apiculi or points they leave on the body of the Ephemerus itſelf; nay, you may likewiſe ſee thoſe little holes which received the apiculi or points juſt mentioned. The pulmonary tubes may be likewiſe ſeen. Why ſhould I ſay any thing of the muſcles, tendons, veſſels, and nerves which are ſeparated from their membranes, like ripe fruit falling from a tree? for neither reaſon, obſervation, nor experience can diſcover any thing of them, ſince they are all directed by the omnipotent wiſdom and providence, and conducted in ſuch a wonderful manner that they are altogether incomprehenſible.

Again, though many parts of the Worm of the Ephemerus are extended and become longer under the firſt change of its skin, yet the horns which project from the fore part of the Worm's head only caſt their skin, and when it is off they become more ſlender and ſhort in the flying Ephemerus than they were in the Worm itſelf. The change that happens about the eyes merits yet greater attention, for their cornea tunica which was of a ſmooth and equal ſurface in the Worm, ſeems in the Ephemerus, after caſting its skin, to conſiſt of a congeries of many eyes, which form a little net equally divided. The legs likewiſe, together with two of the tails, become as long again by the change: but the third or middle tail is entirely taken off, having ſerved no purpoſe but to the Worm.

When I ſay the two eyes of this creature are compoſed of a congeries of leſſer eyes, ſix, nay ſeven thouſand of which I have obſerved thus cluſtered together in ſome inſects, whereas in others, as Spiders and Scorpions, they are diſperſed all over the body; I would not have any one conclude from thence, that theſe eyes are formed as they are in the human ſpecies and other known animals. They are by no means ſuch, for they want the humours; but every globular diviſion of them emits an hexagonal filament like a needle, which terminates in the net-like tunic or coat of the eyes, and this coat itſelf ends at the nerve and brain: ſo that theſe creatures ſee in a different manner from us. We ſee by the aſſiſtance of rays collected on the inſide of our eyes, but theſe perform viſion by a collection of nervous filaments, which, when they ſee, are lightly and gently affected and moved in their prominent extremities by viſible objects, and by the rays of light or colours and other appearances, as I have deſcribed at large, and expreſſed in figures in my treatiſe on Bees.

As to the ſucceeding change of the skin of the Ephemerus, which immediately and without interruption follows the firſt, we are to obſerve therein, that the Ephemerus having once caſt its skin, chooſes no particular place to reſt or ſettle in, in order to undergo the other.

It fixes upon any place it can find in its flight, and it does not regard whether it be wood, ſtone, earth, a tree, a boat, a ſhip, a beaſt, or a man. It ſeems to be a moſt innocent little creature indifferent to every thing, ſo that it can reſt any where, in order to caſt off this ſecond skin, which is done in the manner following.

The Fly firmly and ſtrongly faſtens its legs, which are armed with ſharp claws for that purpoſe; then it appears as if ſeized with a ſhuddering and trembling motion, and immediately its skin opens on the middle of its back in the ſmall ſhield that is placed there: this opening becomes by degrees ſo large towards the fore parts, that the creature can thruſt its head out of it. After this it draws its legs alſo out of the skin, Tab. XIII. fig. XII, XIII. whilſt the claws, adhering to the caſt skin, are in the mean time ſtill firmly fixed in their places; and this indeed contributes much to remove the skin from the reſt of the body. Moreover,

Moreover, it muſt be well obſerved, that the head and legs are ſtript of their ſkin in the ſame manner as we draw our feet out of our ſhoes, or our head out of a narrow cap. But as to the other parts, namely, the firſt and ſecond pair of wings, the ſkin is drawn off from them in ſuch a manner, as that the inſide is turned out and the outſide in, as we invert a limber pair of gloves, the inward ſurface or inſide of the fingers being pulled out. At the time when half the ſkin is drawn off the wings, theſe inſects are as helpleſs captives, and fixed in that condition, fig. XII. they even lie for ſome time without any ſenſible or remarkable motion. The reſt of the body is likewiſe by this ſecond change extended and becomes much longer, and the tails become a third part longer than they were after the firſt change. So that the tail and legs which were made, under the firſt change, a third part longer, are now again as much more lengthened; but this holds more perfectly in the tails than the legs. For, as the tail conſiſts of hollow rings which are capable of being drawn out from each other, hence its extenſion is much more conſpicuous than that of the legs, becauſe the latter only lay folded in the ſkin, but are now extended fully to their length, and nothing more. It is moreover to be obſerved in regard to the tail, that its hairs, which were planted very thick in the Worm of the Ephemerus, are placed more remote from one another when it flies, and they alſo become much finer and thiner, ſince they likewiſe caſt their ſkin twice, and appear iſſuing out of their hairs as out of little ſheaths.

The Ephemerus having thus partly ſhaken and partly drawn off its ſkin, by inverting or turning it inſide out, being now perfect, ſeeks again the water, on the ſurface of which it flies and beats up and down gently and quickly, and, as it ſeems, wantonly ſports and plays, and then reſts again, leaning on its tails, and ſtriking its wings againſt each other. Whilſt the Fly is thus in motion on the ſurface of the water, and looſely playing with its wings, its tail, which is hollow and full of hairs, very eaſily ſupports the body; for, as it contains air in it, it is therefore carried lightly upon the ſurface of the water, and does not ſink under it. Something like this is obſerved in ſeveral other inſects, which will continue in the ſame manner, ſuſpended on the ſurface of the water by the help of hairs, within and between which the air is detained, as is the caſe in the Worms out of which Gnats and Gad-Flies are produced. The air, however, does not always continue in the tails of the Ephemerus, but ſometimes comes out of it, and may at any time be let out if they are pricked with a needle, in order to dry and preſerve them; for then they generally become corrugated or wrinkled, and ſink or fall together. There is alſo another reaſon why the Ephemerus flies thus lightly on the ſurface of the water, and that is, becauſe it carries a ſmall bladder full of air in its body; unleſs we ſhould rather incline to think that it is the ſtomach of the Ephemerus, which is then inflated or blown up with air. But I ſhall affirm nothing certain concerning this matter, ſince it is not ſufficiently clear to myſelf.

The male, fig. VI. as appears to me, changes its ſkin twice, but the female, fig. VIII. only once. I do not, however, advance this as undoubted truth, ſince I have not yet confirmed it by a ſufficient number of experiments. For this reaſon, if it be thus, we obſerve that the tails of the female are a third part ſhorter than the tails of the male. Beſides, another more remarkable difference is, that the eyes in the male are twice as large as in the female. A third difference is, that the yellow colour of the body in the male approaches more to red than in the female. The male likewiſe has, beſides his two larger tails, four appendages, like crooked little tongues, which cannot be ſo diſtinctly ſeen in the female. Theſe are the great differences of the two ſexes.

The Ephemerus does not engender either in the body of the water, or on land, nor in the air, but the female throws out her eggs on the ſurface of the water, and the male afterwards caſteth his ſperm upon them *, and he has probably, for this purpoſe larger eyes given him by the all-ſeeing Creator, that by means of this advantage he may eaſily find out the eggs of the female wherever ſhe has dropped them. As therefore a great many ſpecies of fiſh without coition throw out their eggs into the bottom of the water, to be afterwards impregnated by the male, ſo the Ephemerus throws its ſperm into the water. Theſe eggs, when caſt out, are not collected and concreted together in the form of a perfect ovary, like that which the Ephemerus carries in its body, but are ſeparated and diſperſed from each other as they are in fiſh. That the Ephemerus while a Worm does not perform the buſineſs of coition in the water, is manifeſt from hence, that it does not come out of its cells only at the time it is to caſt its ſkin. Nay, if it ſhould go out of them, as it ſometimes does through neceſſity, or to breathe freſh air, yet it is by no means able to do any act to propagate its ſpecies in the water, for it cannot remain ſuſpended in the water but while ſwimming, and it ſinks immediately to the bottom when it has a mind to reſt in it: but at the bottom it has no fixed reſidence till it has made a new cell or habitation for itſelf. To theſe we may add another, the ſtrongeſt argument of all, that is, that no inſect ever enter upon the buſineſs of

* This, though common with fiſh, is ſtrange among the inſect kind; but in the whole compaſs of natural hiſtory nothing is more variouſly performed than the impregnation of the eggs, nor any thing ſo little underſtood; it ſeems, they may not only be impregnated by a male ſperm caſt upon them when laid by the female, but even by the ſame fluid caſt at random while they are yet in the body of the female. Monſieur Demours is particular in his obſervation of the water Newt, the male of which has no penis, but diſcharges his ſperm in the water near the female, whoſe eggs, though none of the ſperm abſolutely enters her body, are ſo impregnated.

generation,

generation, until they have caſt their laſt skin. At leaſt, I have been taught ſo by all the experience I have had in their examination.

Neither do the Ephemeri breed or engender in the air; this may be eaſily obſerved when they fly. Beſides, they could not poſſibly breed in the air, becauſe the legs of the males are ſo vaſtly lengthened after the laſt change of the skin, that Clutius took them for horns. Thoſe who would favour ſuch an opinion, muſt conſider what an apparatus is neceſſary for ſuch coition in the air; as may be ſeen in thoſe Flies which do it, and particularly in the Libellæ, which perform their venereal embraces in a wonderful manner, flying and wandering all the time in the air, viſibly coupled a long while together.

I therefore conclude from all my obſervations, that the Ephemeri never engender together, either in the air or water, but that the female only throws her eggs on the water, and the male afterwards pours its ſperm, which it carries about it flying, as the female does its eggs, upon them; ſo that this operation is performed without any communication of the two ſexes. All theſe things are haſtily tranſacted in the ſhort period of a moſt tranſitory life, ſo that a more accurate inquiry into them cannot poſſibly be made.

Theſe little creatures do not eat in the whole courſe of their lives, while perfect flying creatures, as is alſo the caſe with many other inſects. I have likewiſe found by experience, that Frogs, Lizards, Serpents and Cameleons, are capable of living without eating many weeks; nay months.

CHAP. IX.

How long the Ephemerus lives, and what haſtens its death.

THE Ephemerus thus flying about and wandering over the ſurface of the water, and moving ſometimes up and ſometimes down through the air, never lives more than four or at moſt five hours, that is from ſix of the clock in the evening, or half an hour after, until eleven at night. This I ſay from experience, becauſe I have carried ſome of them encloſed in a box into my chamber, and there accurately obſerved the length of their lives. All die in this very ſhort ſpace of time, nor do any of them, which is a matter very worthy of obſervation, die a natural death on land. All of them invariably go to the water again, after they have gone through the ſecond change of their skin. God therefore, the ſupreme artiſt, has been pleaſed to aſſign this inſect a ſhort life that ſurpaſſes all adoration.

Who has ſo great a genius, or is ſo converſant in the art of writing, as to be able to deſcribe, with a due ſenſe, the trouble, and misfortunes this creature is ſubject to, during the ſhort continuance of its flying life. For my part, I confeſs I am by no means able to execute this task. Nor do I know whether nature ever produced a more innocent and ſimple little creature, which is, notwithſtanding, deſtined to undergo ſo many miſeries and horrible dangers.

Beſides, that the life of the Ephemerus is ſhort, nay, amazingly and incomprehenſibly ſo, an infinite number of them are always deſtroyed in the birth, being devoured by fiſh. Nor does Clutius acquit any ſpecies of fiſh of this barbarity except the Perch and Pike. Though the reſt of the Ephemeri have eſcaped this cruel danger, yet on land, when they are engaged in the great work of changing their skin, they are barbarouſly devoured by Swallows and other birds. Nay, if they eſcape this danger, when they afterwards approach again to the ſurface of the water, and careleſly ſport and play there with their wings and tails, they a ſecond time become a prey to the fiſh, which drag them away to the dark bottom of the water and devour them. If they fly higher into the air, another kind of torment attends them, for then they are perſecuted with a different barbarity by other kinds of birds, which tear their limbs aſunder and devour them. Though theſe inſects then are the moſt innocent, perhaps, of all others, they are more cruelly treated or uſed than the moſt miſchievous of wild beaſts.

As the Ephemerus abounds with uſeful leſſons and moral precepts, ſo it affords ſufficient matter for various ſpeculations. It is ingendered, grows to its bigneſs, and then generates, lays eggs, caſts its ſperm, grows old, and dies in the ſpace of five hours. This ſhort time comprehends the morning, noon and evening of its life.

When the Ephemerus is flying, and particularly a little before the end of that time, the Trout, which eats it as its food, comes to its perfection: its fleſh and flavour being finer than at any other time. This I have been aſſured of by Nicholas Tulpius, formerly conſul at Amſterdam, for he fairly made trial of the matter.

One may ask further this queſtion, why, excluſive of all thoſe dangers and misfortunes, the life of the Ephemerus ſhould be ſo ſhort? In anſwer to this let it be obſerved, that the eggs of the Ephemerus, whilſt it ſtill ſwims as a Worm, are arrived to their perfection, ſo that as ſoon as the inſect is increaſed and perfected by changing and extending its limbs, thoſe eggs are inſtantly fit for production or birth: to which may be added, that the Ephemerus has not the nouriſhing of its offspring; wherefore God has made this creature likewiſe, more than others, void of reaſon, as the Oſtrich among birds, that He, from whom ſprings all reaſon and knowledge, might take upon himſelf the care of nouriſhing its progeny.

Since therefore this creature aſſumes its winged form only to propagate its ſpecies, it follows, that when this is done, its death is naturally near at hand, and for this purpoſe it ſeems to remain three years hidden in the water and mud, and to undergo after that time its change, and get wings in that form living, till this buſineſs of generation is performed, and then it dies.

CHAP. X.

That the Ephemerus kind flies three days and ſometimes four: certain other ſpecies thereof are alſo deſcribed.

THAT the Ephemeri are changing and flying during three days continually, is known to all who live near the rivers, famous for this annual miracle; I have obſerved them flying the fourth; nay, even the fifth day, but then very few in number. Theſe were a ſucceſſion of the inſects hatched one after another, and hence I think theſe had been Worms of the ſame year, the wings whereof had acquired their maturity ſomewhat ſlower than ſome others; and that theſe latter were ſick, or prevented by ſome other impediment, which hindered their change in the appointed time. As, on the other hand, it is certain that the transformation of the Worms of this ſpecies, which are changed before their time, happens on account of their wings and other parts being perfected earlier than natural. As this may and certainly does happen in all the inſect kinds, I ſee no reaſon why the Ephemerus ſhould not ſometimes be produced in its winged form, ſome days ſooner or later than the ſtrict time, ſince it is certain from experience that the general change of them may happen fourteen days ſooner or later, as the ſeaſon of the year favours it more or leſs.

If we attentively conſider the things that have been here related of the Ephemerus, it is evident that Mouffet ſpeaks truth, when he ſays, "The Ephemeron, or Diaria is a wonderful "Fly, whether we conſider its make or the "ſhortneſs of its life." But ſome of the other particulars related of this inſect by this author, as well as by Aldrovandus, Johnſon, Clutius, and others, who are cited by all the latter writers, do not much correſpond with the truth. Far be it from me to reprehend or animadvert on others in theſe matters; ſince it is poſſible that theſe gentlemen might have deſcribed a different Ephemerus from mine, as there are various ſpecies. Beſides, nature, or her author God, is perfectly inexhauſtible in the make, properties and diſpoſition of theſe creatures. I ſhall only recommend it to any who ſhall be deſirous of knowing the truth, to conſult the inſects themſelves; for nature far ſurpaſſes all the writings and treaties that can be compiled, and in this and all other caſes will teach more in one inſtant of time than any one can learn in a long ſeries of years out of the beſt library.

It aſtoniſhed me to ſee in a book written by Augerius Clutius, that Dortmannus there exhibited a figure of the Ephemerus, deviſed upon a weak and erring memory, or feigned from mere imagination. Goedaert having obſerved this, and being furniſhed with many more obſervations of that kind, undertook to amend it of his own pleaſure, but without ſucceſs; ſince he changed nothing but what appeared to his fancy to be improper, and left the whole figure of the inſect, which was delineated from memory only, altogether incorrect. As he attempted to correct theſe errors from his own imagination, it ſhould ſeem to follow that he multiplied them, although he rendered them more ſeemingly like the truth. Indeed Goedaert himſelf owns he never ſaw this inſect.

While I was engaged in inveſtigating the nature of this inſect, I met with various ſpecies of it at different times, but I never had the good fortune to ſee the Ephemerus of Hoefnagel, which Clutius delineates; and which is found alſo among the figures of Hoefnagel. But I once found its Nymph troden upon in the road that goes by the lake of Deimermeer. I at that time thought it had its origin from a kind of blackiſh and toothed water Worm, which has a cloſely corrugated or wrinkled ſkin; ſince the latter having attained its full bigneſs, leaves the water, and betaking itſelf to land, is there changed into a Nymph, which in proceſs of time, perhaps, acquires the form of the Ephemerus delineated by Hoefnagel. This Ephemerus afterwards throws its eggs into the water, which is the caſe with many other inſects, and with ſeveral other ſpecies of the Ephemerus which I can ſhew. I ſaw and took ſome of thoſe ſpecies in the river Loire at Saumeur in France. Theſe do not differ in their general form from the Ephemerus of our country, but they are leſs, and of a ſomewhat different ſtructure. I have ſeen great ſwarms of theſe flying, when I chanced to walk in the evening on the bridge that is over the river at Saumeur. Some of theſe carried about them their ſecond ſkin ſtill ſticking to their tails, as they flew up and down above the bridge. I have nothing farther to ſay of this kind, or of all other ſpecies which I preſerve, only that ſome of them are as ſhort lived as our Ephemerus, which I have been hitherto deſcribing,

describing; but I have observed that others of them live longer than these. I therefore apprehend that the various species are distinguishable from each other by several further peculiarities; and, for this reason, I do not pronounce those authors reproachable, who relate any thing of these or of the like insects, because what they say does not exactly agree with the species of one particular country. Far be it from me to be guilty of such temerity; since God is infinite in all his works, and the species may be numerous.

About the end of June 1670, when I resided in the village of Slooten near Amsterdam, I went sometimes in the evenings into the fields, where so great a number of minute insects which were somewhat larger than Gnats, at times pitched on my cloaths, that I was all over covered with them. Each of these cast a small skin on my cloaths; after which, I observed that all of them returned to the water, and there, like the larger Ephemerus, sported and beat up and down. These insects are produced nearly in the same manner as the Ephemerus before described; for they live in ditches and water-trenches, and when they are to suffer a change into the Fly state, they likewise, at regular times, cast two skins, one in the water and another on the land. The Worms of the smaller Ephemerus differ from the larger, in that they do not hide themselves in mud, or form cells or long holes, but mostly inhabit stony and sandy bottoms: therefore nature has formed them of a rougher and more robust constitution than the larger Ephemerus. Their skin also is more like the crustaceous integument of Crabs and Shrimps. They have likewise branchiæ or gills, and rowing fins on the sides of their bodies. When in the middle of summer any one takes up stones from the Rhine or Leck, or other collections of waters in our own country, for carrying to the land, he will most commonly see some Worms of that kind sticking to them; which is likewise the case in other countries and other rivers, as I myself have learned from experience in the Loire, the Seine, and other rivers of France. Hence it is evident that there are many distinct species of the Ephemerus, and that the authors who describe an Ephemerus, however different from that of our country, do not merit certain censure. I can for the most part exhibit to the naked eye the Worms before mentioned, and every thing that I have hitherto advanced concerning the Ephemerus, according as they are in nature; since I have preserved them to this day, that they may serve the better to illustrate and confirm what is said in this treatise.

The end of the wonderful history of the EPHEMERUS.

The THIRD ORDER.

Of natural changes, or slow accretions of the parts of insects.

HAVING explained in the preceding chapters the two first orders or classes of natural changes, we now advance to the third; which, we must observe, is always preceded by another change, as we have before described at large.

As this change is more obscure and intricate than the first, and more difficult to be understood than the second, in order to give a distinct and plain description thereof, we shall compare it with the first and second; for by this means it will be easier to comprehend what they all three have in common, and in what they differ from each other. As the first order of transmutations consist in this, that the creature increases in its parent from almost invisible, but really existing rudiments, and lies enclosed in a membrane until it has acquired sufficient strength therein to be able to creep out of it; so on the other hand, the other order is much more imperfect; for in this the insect increases likewise as in the first order, but it comes out of its egg imperfect; and therefore because in some parts, but chiefly in regard to the wings, it is still defective; it must, in order to acquire its due perfection, take in food from abroad; by the help of which, the rest of its parts, which we from time to time observe to increase and expand, like a flower from its cup, are at length perfected.

The order of nature is quite contrary in those insects which undergo the change of our third order: for though they increase in the same manner as those in the first order, and come forth imperfect, as those in the second order, nay, much more so, out of their egg, many of them not having even legs; yet all these imperfect parts are increased and augmented in a very obscure manner under the skin. Hence, as the creature issues complete in all its parts out of the egg in the first order, and in the second the accretion or expanding of its several parts is performed externally and openly; but in this our third order, on the contrary, this germination or sprouting is all transacted within the covering of a skin, and can with very great difficulty be observed, unless by the change of the skin.

As therefore those insects which undergo the first order of transmutation, constituted under the form of a Nymph, creep only simply out of their egg or skin: and as those which belong to the second order of changes, likewise likewife expand afterwards as it were into a fecond Nymph; though in the mean time they do not ceafe to move and eat, nor do they ever at any period of their lives lofe their motion; fo on the contrary the matter is quite otherwife in thofe which are fubject to our third order of tranfmutation; for as foon as thefe which firft iffued imperfect out of their egg or former Nymph, and increafed in their parts as they have grown under the fkin, like a flower in a tender flower cup, and afterwards caft this fkin by the force of the protuberant parts; under this other transformation they entirely lofe all their motion, except that of the tail only; for this is not fwollen with moifture in a great many, and only changes its skin.

The infects which undergo this third order of change, are produced imperfect out of their egg, and want at that time a great many of their parts: but they by degrees acquire them under the cover of their skin, where they are gradually perfected and enlarged. The legs, wing, horns, and the reft of their parts are by this means increafed to their due fize with the body: this is performed infenfibly by abfolute growth or addition of parts. Finally when the limbs are come to the full period of their increafe, they raife the skin with a vifible fwelling and render it fomewhat prominent in different parts; and under thefe protuberances of the skin, we can plainly difcern the feveral limbs and other parts which lie difpofed in a wonderful manner under that covering, like a flower growing flowly in its cup; until, after the skin is at length caft, all thefe parts very clearly and diftinctly prefent themfelves to our view: at that time the veil, if I may be allowed the expreffion, is at length removed, and all the impediments which till then obftructed the fight, and which have produced fo many errors amongft all the naturalifts without exception, is removed, and all is made plain and eafy. Hence it is, that we can very eafily exhibit to the eye all the parts which before lay under the skin; as I have actually done in the prefence of Thevenot and Magallotti, who accompanied me in thefe experiments, and whofe teftimony is fufficient to put the matter beyond doubt.

We call this change with Ariftotle, Pliny, and others, the Nymph; becaufe we fee iffuing out of it a perfect infect, fit for propagating its fpecies, and adorned in all the fplendour and beauty of its kind, as a virgin in a very rich nuptial garment: the creature having thus paffed the infantine years of a Worm or Caterpillar, comes forth without delay to meet its fellow of the other fex in the fpacious and beautiful tapeftry of the fields, fpread for its ufe by nature.

On thefe principles our third order of natural tranfmutations confifts; the Worm, after it has caft off the form of a Nymph, in which it lay without food in its egg, is afterwards increafed by degrees, and acquires more parts by the help of the food it is fupplied with, until at length it cafts its skin, and attains the form of a fecond Nymph, which clearly and diftinctly exhibits all the limbs perfect in all their parts, and is once again deprived of all motion as it was before in the egg: this motion is again reftored afterwards in a few days by the evaporation of the fuperfluous moifture.

Thefe infects are therefore twice held in the ftate of a Nymph; that is, firft in the egg, which is their firft Nymph; then in the laft change or fecond Nymph. But there is this confiderable difference in the two, that when they are in their firft Nymph or in the egg, their limbs cannot only be lefs diftinctly feen, than in the fecond, the reafon of which we fhall affign hereafter; but alfo that before they are changed into the firft Nymph or egg, they have no remarkable motion preceding, nor are they increafed in their limbs in any manner different from other infects, or from the feeds of plants. On the other hand, before they are changed by accretion into the fecond Nymph, they do not only evidently move themfelves from place to place, but alfo increafe in the fame manner as other infects during their growth, which have the power of moving or going where they pleafe, and take their food in at their mouths. This being well underftood, the difference between the firft change which is called an egg, and the fecond which we call a Nymph, is very evident; though each of them is only an accretion continued in the limbs though in different manners. We beg the reader will attentively regard what has been hitherto faid, becaufe it is of the higheft ufe, and eradicates entirely the falfe notion of a metamorphofis or change of one creature into another, that univerfal chimera of erring opinions, and totally deftroys and fubverts the monftrous opinion of a fortuitous generation of creatures.

As the parts of the future infect are feen much more plainly and diftinctly in fome of thefe Nymphs than in others, as Ariftotle, though not perfectly right in this matter, has likewife obferved; we fhall therefore divide them into two kinds, in order to make the underftanding of them more diftinct: that is, we fhall call one of thefe a Nymph fimply; and the other the Nymph Chryfalis. Nor fhall we regard that the word Nymph Chryfalis does not perfectly or exactly exprefs the thing itfelf; and that all the Nymphs, which we call Chryfallides, are not of that gold colour, whence the name: for we have not judged it proper to depart from the received appellations, or to make profeffed innovations in the terms: fo far are we from this intent, that our great induftry and ftudy are employed to find out truth, and, when found, to explain her fimply and in her natural ornaments. Hence we have refolved to perfuade no body to believe more than what may be fhewn plainly to the eye, and with due attention obferved by every one, as well as by us, in nature herfelf.

A cata-

A catalogue of the insects which belong to the third order or class of natural changes, which I call the Nymph.

AMONG these insects which are changed according to the first method or species of the third order, and, by the power of the increasing and expanding limbs, which breaking open the skin, obtain the form of a Nymph, wherein all the parts appear to be finely and beautifully expressed, I first reckon Bees. I preserve in my collection their queen, as she is called; and also several of the drones, which are properly males; and also the working Bees, which are of neither masculine nor feminine sex; since the proper organs neither of male nor female are to be found in them: whereas those organs are very distinctly conspicuous in the queen and in the drones. This queen has been improperly called the king. I discovered the egg-bag of the female, or king, as it used to be called, in the presence of the incomparable anatomist D. John Van Horne, professor of anatomy and surgery; being assisted therein by the singular favour of Dr. W. V. Hoorn, a physician of Slooten, who readily gave us admittance to his bee-hives.

I likewise preserve the Nymph of the drones, of the queen, and of the working Bees. I can likewise exhibit their webs, which are like those of Silk-worms, and also the honey-combs; between which are the cells or houses of the drones and queen, and working Bees, besides many other things very worthy of observation concerning these little cells; for I have prepared them different ways, that the most artificial order wherewith they are constructed might be made evident. I likewise keep in my cabinet the sting of that usually called the king, and its bag of poison; as also the bag and the sting of the working Bees, which I have found to be divided into three parts. In fine, I preserve also in this collection the testicles and penis of the drones.

It is worthy observation in Bees, as well as other insects, that the lungs are found most distinctly conspicuous in them, consisting of two white bladders. But in insects which have blood, and are by that distinguished from these, the lungs, when cleaned from their humours, are only composed of bladders, as the celebrated Marcellus Malpighius has most accurately shewn: nay, I shall scarce scruple to assert the same thing of the other viscera; excepting only that the skin and the other membranes are interwoven with small and scarce perceptible closed arteries, veins, and the like. These vessels I have also observed are sometimes again opened by the inexplicable power of nature.

The elegant and amazing structure of the rest of the viscera in Bees merits the highest admiration. But as we shall hereafter describe them severally and at large, we shall now say nothing more on them, for as we here treat only in general of these insects: we can only treat of them in general terms before their particular history to be hereafter exhibited.

Considering however that wonderful republic of Bees, which is founded upon affection only, and excludes all kind of superiority, we cannot but exclaim that nature has concealed in the history and manners of these creatures, treasures of inestimable miracles, which are notwithstanding freely opened to us, provided we diligently investigate the disposition of those creatures. An unwearied scrutiny is the only key to nature; nor is there any other than this, which can open the way into her mysteries.

After the hive Bee, we are to name the Bees that live at large in gardens, fields, and forests, and hence are called wild Bees. I preserve six species of these, among which there is one with very long horns; another has an extremely rough hairy body; and a third is extremely like a Wasp: I have exhibited some of these in their natural size, in fig. IV. V. VI. VII. VIII. Tab. XXVI.

I likewise reckon in this third order the wood Bees of Aldrovandus, or that called the solitary Wasp by Mouffet. Their Nymphs, the web of the Worm, and the Bee itself are in my cabinet. I can likewise shew the little nests which these creatures make of small stones, grains of sand, and dirt. In these nests we sometimes find a very remarkable Wasp, together with a Beetle, and the Worm out of which the Beetle is produced: nay, that Vermicle or Worm was once in my possession changed in the exact space of one year into such a Beetle, having had no other food in the mean time but little stones and dirt. These observations create some doubt which of the three beforementioned insects builds the nests just now mentioned; but to me it appears very certain, that the wood Bee is their architect; for she carries the little stones, and the nest itself is found to be appropriated only to her. Such nests are found in great numbers in the ruins of walls in France.

We might likewise mention the Apes Mansuetæ of Mouffet here, but because they belong to our fourth order, and are not Bees but real Flies, we shall therefore describe them hereafter in their proper place.

Next follow the Wasps; of these I preserve seven kinds, together with the combs, in which some of their Nymphs still lie enclosed and sealed up as it were. I have shewn the proboscis of the common kind of Wasps, in Tab. XVII. fig. VII. the poison bladder in Tab. XVIII. fig. IV. and lastly the ovary, in Tab. XIX. fig. IV. In Tab. XXVI. fig. X.

 I ex-

I exhibit one of the largeſt kinds of Waſps, and another uncommon kind in fig. II. ibid. to theſe I have finally added, fig. XIV. XV. ſome Waſps of the ſmalleſt kind. I have more than once obſerved, that the Waſps carry the matter whereof they make their neſts upon their legs.

In this order I rank alſo the Pſeudopheca, which we uſually ſee produced out of a Chryſalis, which is underſtood to be corrupted or rotten: I preſerve twenty kinds of theſe in my collection. Hoefnagel has given us delineations of twenty-four; Goedaert likewiſe deſcribed a few. We may properly inſert this kind of Fly in our fourth order, as will appear when we come to that part.

Among the Pſeudophecæ which we keep, is the Muſca Triſeta, or Three-Hair-Tailed-Fly of Mouffet, whereof I preſerve four kinds. I have repreſented one of them in Tab. XXVI. fig. XIII. and ſome ſmaller ones, in Tab. XLIV. and XLV. I preſerve alſo, amongſt the ſaid Pſeudophecæ, the Muſca Uniſeta, or Single-Hair-Fly of Mouffet, indeed two ſpecies thereof, together with the Worm and Nymph; the Chryſalis, which afforded theſe, is likewiſe in my muſeum, from which, when rotten, this Fly has its origin. I preſerve alſo ſeveral other exotic and more uncommon kinds of Pſeudophecæ, of which I ſhall have an opportunity to ſpeak in my particular obſervations.

To this third order, we likewiſe refer the inſect, called by Goedaert, Devorator, or the Devourer. This is that ſpecies of Pſeudophecæ, which kills Spiders, and may therefore be properly called the Ichneumon Waſp. This Waſp ſeems to be ſomewhat of the like diſpoſition with the Muſca Lupus, or Wolf-Fly; for as the former grinds or breaks her food with her teeth, this latter pierces it with her aculeus.

I likewiſe keep in my muſeum the Flies called Panopes, which are deſtructive of grapes, and may properly enough be referred to the genus of Pſeudophecæ. I have found from obſervation, that theſe Flies are not invariably diſpoſed to one kind of food, but will, when they cannot meet with grapes, ſatiate themſelves with any other food they can find.

Next follow the Hornets: I preſerve two ſpecies of theſe, together with the web, which their Worms form; I can alſo exhibit their Nymphs, and the caſes wherein they encloſe thoſe Nymphs. Theſe creatures are ſo voracious, that if they are cut through the middle they will not quit their food, and if that be fluid, I have ſeen them eat while it ran out of the wound; this I have often experienced with a little honey. We exhibit the largeſt ſpecies of Hornets in Tab. XXVI. fig. IX. and one of their cells in Tab. XXIII. fig. XV.

The humble Bee alſo belongs to this order, whereof there are eight ſpecies, among which I preſerve the exotic one with purple wings. In the figures of Hoefnagel there are likewiſe found eight ſpecies. Goedaert has alſo deſcribed the Worm of the humble Bee kind. I have repreſented the neſt of one of them in Tab. XXVI. fig. I. and afterwards one of the Bees of the middle ſize in fig. XII.

Further, I aſcribe the Gnat to this order; this creature is produced in the water, as will be ſhewn in its particular hiſtory; this it might be proper to ſubjoin immediately to the treatiſe of Bees; but as the Nymph of the Rhinoceros Beetle, on account of its remarkable bigneſs and peculiar ſtructure, throws great light on the ſyſtem of this order, we ſhall firſt give a deſcription thereof.

The Muſca Chryſopis, or Golden Eye, I preſerve alſo in my collection, and have two diſtinct ſpecies thereof. Goedaert has likewiſe deſcribed two ſpecies of this elegant inſect.

I likewiſe have the Muſca Florilega, or Flower Fly, which is black, and a great enemy to young flowers; whole armies of this kind ſometimes inſtantaneouſly poſſeſs fields and gardens. They are ſaid to come out of the water, which I ſhould the more eaſily allow, becauſe I know a great many kinds of inſects, which, after having been in the water ſometime, fly out of it at once; thus myriads of the Libellæ, or Dragon-Flies, fly together, at one and the ſame time, out of the water, as do likewiſe Gnats, Ephemeri, and many other ſpecies. On obſerving this, many have erroneouſly perſuaded themſelves that theſe inſects are produced in the air itſelf. But it is particularly worthy of obſervation, that the Ephemerus always dies a little after its birth; whereas, on the contrary, other inſects remain a long time on the earth alive: the reaſons of which difference we have aſſigned in our obſervations on the hiſtory of the Ephemerus.

I likewiſe preſerve the Fly that is like the Butterfly kind, and the Scorpion-Fly, male and female; as alſo the Wolf-Fly, of which I have five ſpecies. The carnivorous Fly, called the Cæſar, is alſo to be found in my muſeum. I can likewiſe exhibit fourteen ſpecies of the common Flies, and twenty-four ſpecies of the more uncommon kind; ſome of theſe have wings adorned as it were with the figures of ſerpents, ſome diſtinguiſhed with faſciæ or wreaths, ſome with ſpots, and others with grooves or furrows, ſome of them alſo have the belly and breaſt variouſly painted with red, green, yellow and gold. We ſee delineated in the figures of Hoefnagel, twenty-five ſpecies of the common, and thirty ſpecies of very rare, Flies; and the induſtrious Goedaert has left us the figures of forty-eight ſpecies of Flies. Hence, when I conſider the great diligence of that naturaliſt, I cannot ſufficiently admire, that he has been always ſo much a ſtranger to the true knowledge of theſe things; but I muſt add that it happened unfortunately, that his thoughts were committed to writing by others; who, mixing their own chimerical notions

notions with his, involved the true knowledge of thefe matters in greater darknefs.

To this order are likewife to be referred fome very fmall and uncommon Flies of peculiar origin, fome of which are produced from the tubercles or warts of willows, Tab. XLIV. fig. v; others fpring from the alæ or bofoms of the leaves of the willow tree, Tab. XLIV. fig. xv; others iffue from the rofe willows, Tab. XLIV. fig. xvii; others from downy matter or flocks of the catkins, Tab. XLV. fig. viii; others from the ftinging nettle, Tab. XLV. fig. v; others from the fpunge of the dog-rofe, eglantine, or fweet brier, Tab. XLV. fig. ii; others from the excrefcences of oak, Tab. XLV. fig. xix; and laftly, others are produced from a kind of Worms that walk with their fheath or cafe, Tab. XLV. fig. xxxiii. and xxxiv. I have defcribed all thefe little Flies in the fourth order, becaufe they perform their change in the manner peculiar to that diftinction.

The Ant likewife belongs to this clafs, but as we fhall treat of this infect hereafter in our particular obfervations, it may fuffice to fay here, that I preferve both the winged male Ant, and the female, the body of which is fomewhat thicker; and the labouring Ant, which has no wings, nor does it feem to be either of the male or female fex. It is worthy of obfervation, that this little creature is obliged to carry its young wherever they can have nourifhment at hand; whereas others, in general, carry the food to their young; other infects, in a manner different from either of the two former, expofe their iffue, as if they were orphans, and oblige them at firft to find nourifhment for themfelves. The firft fpecies is indeed very induftrious; the fecond gentle and good-natured; but the third, unmerciful, and refembles a cruel ftepmother. However, the great Creator of them, who does not defpife the cries even of the Raven, Job. xxxix. preferves them all.

I moreover keep, a thing very wonderful, five hundred and forty-five Flies of one and the fame fpecies, which have been likewife produced from four Chryfallides of one fpecies of the diurnal Butterfly; fo that the life and motion of thefe four creatures feems to have tranfmigrated into thofe of the five hundred and forty-five others. I can fhew alfo one hundred and eighty-feven little Flies, which burft out of only one Chryfalis that had been wounded. I have likewife one hundred and forty-five, feventy-feven, thirty-nine, and eighteen little Flies of different fizes, which have been changed into Nymphs, in the bowels of diurnal Butterflies, which belong to fo many different fpecies; but I fhall treat of thefe more accurately in the fourth order.

The Tipula Terreftris, or Long-legs of the land, belongs alfo to this order, which Aldrovandus defcribes under the name of the largeft Gnat, but Mouffet calls it Tipula. There are five fpecies of this in my mufeum, but Hoefnagel delineates no lefs than fixteen. This infect is produced from a Vermicle or Worm which commonly lies under the grafs, and is called by the fifhermen, in our language, Im or Imme. I preferve two Nymphs thereof, wherein the parts of the infect are reprefented tho' fomewhat obfcurely; fo that they may be likewife referred to the Chyfallides: the difference is not very confiderable. I likewife have a very obfcure delineation of one of thefe Nymphs by Goedaert.

Next in this order follow the Beetles, whereof I preferve nine of the largeft kinds, twenty-one of the middling, thirty-feven of a fmaller, and one hundred and thirty-fix of the leaft kind. Among thefe there are twenty-five exoticks, brought from the Eaft and Weft Indies, Ægypt, Brafil, France, and other parts. Hoefnagel has likewife delineated thirty-five fpecies of the common Beetles, and feven more rare and uncommon. We find nineteen fpecies of the fmall Beetles defcribed in Goedaert, to which are added five of their Nymphs, indeed very beautifully delineated. I preferve likewife feven Nymphs of Beetles, and among thefe the Scarabæus Naficornis, or Rhinoceros Beetle.

What deferves very particular notice in the Beetle, as Fabricius ab Aquapendento has juftly obferved, is, that the bones, which in larger creatures which have blood are placed in the infide, are fituated on the outfide in the Beetle. And, on the contrary, the flefh, which lies on the outfide in fanguiferous animals, is here hedged on the infide within the bones, or horny fubftance of thefe infects. Another thing which merits the greateft attention is, that in the very mufcles of thefe little creatures is difcovered the fame ftructure, that the great anatomift Nicholas Steno obferved in thofe of the larger animals. This is particularly remarkable in the ftructure of the mufcles of the Locuft's legs, by the help of which that creature can leap up and down fo nimbly, that it raifes itfelf into the air two hundred times the height of its body.

As nature fhews herfelf wonderful in the fimilar ftructure of the mufcles given to thefe two kinds of creatures, fo indeed does that great immenfe difference, which is between the bones of the larger or fanguiferous animals, and the horn-like texture of the little bones in infects. Among thefe infect tribes, nothing is more various, or can be more worthy of notice, than that exceeding great, and at the fame time beautiful diverfity of ftructure, which is to be met with in the horns of the Beetle kind. I really think that according to this diverfity alone the diftinctions of the Beetles into fpecies may be determined.

I preferve feven fpecies of the Scarabæi Naficornes, or nofe horned Beetles, among which there is one; whereof the horn is bent like a bow, or arch-like, towards the back or fhoulders. I can fhew the curious this creature, together with the lice wherewith it is infefted. But I have

have obferved, that it is produced from the largeft fpecies of Coffi or Hexapode Worms *, which are in the exact fpace of two, and fome of three, years changed into Nymphs. Befides this horn upon the nofe, it has two horns which arife near the eyes, and terminate as it were in knotty extremities. I fhall give its whole peculiar hiftory in its proper place. I preferve befides this two other nofe horned Beetles, which are very fmall, and have the horns divided in a manner into two parts. I can likewife fhew another fpecies of the unicorn Beetle, which has the horn likewife bent like a bow or arch towards the breaft, and ferrated on the inner part with four teeth: whilft in the mean time the bony coverings of the fhoulder, loins, and breaft, are ftretched vaftly forward, and terminated in this horn, which is planted in the concave part of its arch with briftly hairs, of a gold colour, and foft like velvet. I have likewife two other nofe horned Beetles, which have the horns undivided in their originations, but afterwards terminate in fplit points. In thefe Beetles the breaft bone is likewife black, horny and divided, and terminates in one of their horns, which is as it were ferrated at one end; but at the other divides itfelf into two obtufe horns. The laft named fpecies of the Beetle is alfo adorned with very fingular and knotty horns placed near the eyes. I exhibit alfo five fpecies of thefe exotic Naficornes, or nofe horned Beetles, of their natural fize, in Tab. XXX. fig. 2, 3, 4, 5, and 6. The largeft Beetle that I have in my collection, is, together with its horn, fix inches long, and its body half an inch broad: if its wings be expanded, they meafure feven inches.

I preferve with thefe in my cabinet, the Beetle called the flying Stag, or flying Bull; the Lucanus, or Stag-horned Beetle, the male whereof is horned, but the female, as is commonly afferted, has no horns. It is very remarkable in this as well as in the other infects of this kind, that their wings are hidden and folded as it were within little fheaths, from whence they have obtained the name of vaginipennæ, or fheath-winged. We likewife obferve when thefe infects fly, that thefe little fheaths, or cafes, wherewith the wings are at at other times covered, are only elevated, and are not agitated by the motion in flying. There is nothing in this flying Stag more worthy of notice, than the probofcis or trunk wherewith its fwallows its food: this food is a juice like honey, oozing out of the oak. This trunk is delineated among the figures of Hoefnagel, which are indeed the beft and moft accurate of all the figures I have hitherto feen. I can exhibit the method whereby the wings lie folded under the outer pair beforementioned; we are not to fay they are in reality plaited, for they are rather contracted by the affiftance of joints. I have obferved that thefe joints are placed almoft in the extremities of the wings, and are moved by the help of peculiar mufcles; hence a fluid likewife drops from them when they are wounded, which is not the cafe when wings are merely membranous. When I offered a little honey on the point of a knife to one of thefe Beetles, it followed me like a dog, and fucked the honey very greedily with its trunk.

Befides thefe, I can likewife fhew twenty-one fpecies of the Capricorn Beetles. Thefe creatures have all wonderfully long horns. Some of thefe which I preferve are furnifhed with branching and prickly horns with knotty and fhort joints; and the horns of others are divided into very long, equal, and as it were knotlefs joints, fome of them are fomewhat fituated in the middle, and are knotty again where they are joined to each other. The body of the largeft Capricorn Beetle I have is above four inches and an half long, and the horns are as long as the body. I have likewife another above two inches long, which is covered with prominent party-coloured hairs like a Turkifh carpeting, and makes a wonderfully beautiful figure: its fore legs are much longer than the reft. Moreover, I have a fpecies of thefe flying Capricorn Beetles, which has very tender legs and horns; which, however, are confiderably thick about the bending of the joints, and where the mufcles are inferted. I have likewife a Wafp with this kind of knotty joints.

With thefe I preferve feventeen of the flying Capricorns with much fhorter horns. Among thefe there is a kind of Beetle, that vibrates its wings with fo much velocity, that it is with very great difficulty to be taken, and hence we have called it the flying Beetle. A thing extremely wonderful in this Beetle is, that its teeth are on the infide full of ramifications, by which ftructure it is indeed diftinguifhed from all others. This Beetle flies in the day-time, and is the fame with the fourth and uncommon fpecies of the Stag Beetle of Mouffet.

I have moreover nine fpecies of the faid flying Capricorns, having ftill fhorter and fmaller horns.

I likewife infert the Cicindula or Glow-Worm, which is of the Beetle kind, in this order. It indeed refembles a flying diamond or little ftar; it glitters with as much light, when it is yet a Worm with fix legs, as when it is changed into a perfect Beetle: in that ftate it muft firft elevate the fheaths or cafes of its wings, or at leaft ftretch out its tail or the extremity of its abdomen, in order to difclofe its light.

Laftly, among my Beetles are thirty-two fpecies, furnifhed with horns that have knobs at the tops of them. Thefe globules of the horns are indeed conftructed in a moft wonderful manner, for fome of them refemble bunches of grapes, others are like the leaves of an open

* As all Butterflies are produced from Caterpillars, all Beetles are produced from Hexapode Worms. Some of thefe live on land, fome in water; but they are in general all longer lived creatures than Caterpillars.

book,

book, and others again are of various different ſtructures. One may by the help of theſe horns very eaſily diſtinguiſh the male from the female. This is likewiſe the caſe in the nocturnal or night Butterflies, for their males may by this ſign be very eaſily diſtinguiſhed from their females, while they are ſtill in the Nymph ſtate. Of theſe ſpecies of Beetles ſome are oblong, others round, others ſhort, others indented, ſerrated, party coloured, or variegated and ſprinkled over as it were with duſt or meal, rough with ſmall tubercles, ſquares or cheques, or conſpicuous by their ſpots and various other ornaments. Among theſe I can likewiſe ſhew a Beetle found in the neſts of wild Bees, and delineated in Tab. XXVI. fig. III. Almoſt all theſe Beetles fly at night.

I refer alſo to this order the common dung Beetle, which has its horns terminated by knobs. I have two ſpecies of this, which, like the blue black Beetles, emit a bright and glowing light; one of them is conſpicuous by a purpliſh gloſs, like that of copper, on its breaſt and belly: the other glitters like green molten braſs or copper delicately gilt, and indeed makes a very beautiful figure.

I have moreover four ſpecies of the Bupreſtes, or green, gold, and yellow Beetles, which are of an offenſive ſmell; the horns of theſe are formed like thoſe of the Capricorn Beetles, and the males are ſmaller than the females. I have likewiſe another ſpecies which ſmells like a roſe.

I keep alſo four ſpecies of the Cantharides, to which I think the former in reſpect to their qualities and virtue are nearly related. I have likewiſe the eggs of the common golden yellow Beetle, which are like mother-of-pearl. Some of theſe inſects have knotty horns, and others have them formed like thoſe of the Capricorn Beetle. Among theſe I can ſhew a very beautiful Beetle, the body of which is adorned with little apertures and impreſſed furrows. This was given me by the very celebrated Dr. William Piſo, formerly principal phyſician to his highneſs prince Maurice of Naſſau.

I can likewiſe ſhew the Indian Beetle, the ſheaths or caſes of whoſe wings are of a ſhining black like ebony, and have many little indentings, wherein are ſeen little oblong feathers adorned with all kinds of colours, bright as any kind of gems whatſoever.

I likewiſe reckon the Curculio or Weavil in this order; which, from a Worm deſtructive to corn, is changed into a Beetle, and of which a magnified delineation may be ſeen in Redi. Aldrovandus deſcribes a Weavil which is changed into a Butterfly, and indeed belongs to the ſame order, but to the third ſpecies of it.

I preſerve alſo ſix ſpecies of Beetles with long necks and Hogs noſes, which I therefore call flying Hogs, or Hog Beetles.

Next follows the Proſcarabæus, Vermiculus, Majalis, or May-Worm, which, as well as others we likewiſe think referrable to this order. We have three ſpecies thereof, two of which have horns like thoſe of the Capricorn Beetles; but thoſe of the third are knotty. Goedaert has likewiſe deſcribed a Vermicle as belonging to the laſt, but he has very prepoſterouſly joined them together.

To theſe I add the Staphilinus, which, ſeeming of a middle nature between the Beetle and Scolopendra, can very quickly kill Earthworms with its teeth, and afterwards ſuck them. Goedaert has committed three errors concerning this inſect, which we ſhall hereafter explain and ſet right. This inſect and the Worm from which it is produced are likewiſe deſcribed by Mouffet. I preſerve five ſpecies of it, together with the Worm and Nymph, which exhibits the parts of the future inſects but ſomewhat obſcurely. Theſe inſects have horns like thoſe of Capricorn Beetles, but their wings are complicated in a very uncommon manner.

I preſerve beſide theſe four ſpecies of Beetles, which, whether they lie on their back or belly, can contract and preſs their head and breaſt cloſe to the ground, and jump into the air: wherefore we think that the name of Graſshopper or Locuſt Beetle is a proper one for them.

I have likewiſe the ſmall Beetle, which, having firmly and ſtrongly fixed its foremoſt legs, and bent and put its head through the ſpace between them, makes a continual noiſe in old pieces of wood, walls and cielings, which is ſometimes ſo loud, that, upon hearing it, people have been perſuaded that nocturnal hobgoblins, ghoſts, or fairies wandered about them. I think that this may be properly called Sonicephalus, or the noiſy-headed Beetle. Other ſpecies of Beetles make a ſtrange noiſe by rubbing their head againſt their breaſt, and others preſs their tail or belly cloſe to the ſheaths or caſes of their wings, and by that means make alſo an uncommon creaking.

I have alſo four ſpecies of the Scarabæi Teſtudinati, or Tortoiſe Beetles, and ſome of their Worms and Nymphs. Goedaert has likewiſe deſcribed two ſpecies of theſe.

I alſo have the Scarabæus Aculeatus or ſtinging Beetle, with its tail formed like an aculeus or ſting, which is not met with in any other of the Beetle kind.

Moreover, I can ſhew a very ſmall Beetle with its Nymph, which is produced out of a Worm without legs, and is found hid within the outer ſkin of the leaf of the ſallow tree. This Worm has its food there ready and ſufficient for it, until it is at length changed into a perfect Nymph in all its parts. I have deſcribed the whole change of this Beetle, which is carried on very obſcurely, in the fourth order, and have exhibited its figures in Tab. XLIV. fig. XII. XIII, &c.

I have moreover a deteſtable Beetle, produced from a Worm that eats the roots of ginſeng, and is changed into a Nymph within that precious drug. The ſame is likewiſe found in old logs of wood.

I like-

I likewife keep thofe Beetles, with their Nymphs, which are produced from Worms that gnaw dried flefh. By the affiftance of thefe Worms a fkeleton may be eafily cleared of the flefh that fticks to it.

I am alfo to add that I have a Beetle, the Worms of which eat the bag of the mufk; I have, on account of the obfcure manner of its changing, defcribed it under the fourth order, and given its figure in Tab. XLV. fig. XXXII.

Laftly, I rank in this order the largeft, the middling, and the fmalleft Hydrocanthari, or Water Beetles, concerning which I have occafionally inferted various obfervations of the greateft importance to the naturalift. I preferve five fpecies of thefe; the fmalleft is called the common water Flea, and water Fæmella. When this dives under the water, it has the art to enclofe a little bubble of air very dexteroufly in its tail. I have reprefented the parts of generation of the Hydrocantharus, in Tab. XXII. fig. V. and the Worm called Vermis Sicarius, out of which it is probably produced, is exhibited in Tab. XXIX. fig. IV. and V.

The third order or clafs of natural changes, according to the firft fpecies or method, which we have called fimply the Nymph, exemplified in the Ant.

Tab. XVI.

No. I. THE Ant's egg delineated in its natural fize, or the Worm of the Ant in its firft skin or coat, wherein it is called the egg. The firft of thefe figures exhibits it magnified.

II. Is the skin beforementioned after it is caft. This is a kind of thin membrane, which the Vermicle or Worm of the Ant, quitting the form of an egg, throws off loofely, and rolls up as into an imperceptible point.

III. The Ant's Vermicle or Worm, imperfect in many of its parts, without legs, come out of its egg or skin, and here reprefented in the form wherein it is commonly found in the earth at that period; that is, having its head bent towards its breaft. Figure II. exhibits a microfcopic view of it.

IV. The Ant's Vermicle or Worm having attained its full bignefs; that is, when all the limbs and parts proper to the Ant are already increafed under the skin, but ftill lie hidden. Figure III. gives it as feen under the microfcope.

V. The former Vermicle or Worm, having caft its skin and expofing to view all its parts, which were before hidden; It fhould therefore be now called a real Nymph, whofe limbs are fwollen with a fluid matter, as will be made more evident in the explanation of the fourth, fifth, and fixth figures, which exhibit the fame ftate of the creature magnified, together with its feveral parts.

VI. The fame Worm now come into the ftate of the Formica or Ant, as will be more accurately and largely defcribed in the fubfequent explanations of the figures.

Tab. XVI. Fig. I.

The Ant's egg magnified, perfectly fmooth and equal, diftended, glittering, and without any annular divifions. This is naturally fo fmall that when placed on a black ground it is fcarce vifible to the naked eye. This muft be well obferved in order to diftinguifh the true or real egg of the Ant.

Fig. II.

The Vermicle or Worm of the Ant delineated larger, and prefenting its head and mouth, together with the twelve annular divifions of its body. The head is bent towards the breaft; and if the Worm be touched or moved in the leaft, it always contracts itfelf in that manner. Though this be a real Vermicle, yet it is commonly called the egg of the Ant. But this appellation proceeds from the groffeft ignorance, fince it palpably is a real creature, having life and motion, though it is yet without legs: it does not bear the leaft refemblance to an egg, nay it is fometimes larger than the Ant itfelf. But fuch is the ignorance of thofe perfons who feek for thefe Vermicles and expofe them to fale in the market: they are bought there in order to be given as food to various kinds of birds, and they are very greedily eaten by them.

Fig. III.

I here exhibit the method whereby the Vermicle or Worm beforementioned leifurely and quietly undergoes its natural change; the blood and other humours infenfibly fwelling about the breaft and near the head, and by that means the creature itfelf becoming thicker, larger, and more fwollen: by this means at length lofes all its motion, that is when it has caft its skin, and brought to light its limbs, that were before hidden.

Fig. IV.

The fame Vermicle or Worm, having caft its firft skin, and prefenting to view all its limbs and parts, which were before hidden under the skin; hence it is in this ftate called a Nymph, which I reprefent magnified, and reclining on its fide.

Fig. V.

The fame Vermicle, lying on its back, is in this figure expreffed magnified.

Fig.

Fig. vi.

The fame Vermicle or Worm is here again exhibited, and all its members are diftinguifhed by letters annexed: hence it is indeed very evident that the Nymph is the real infect, but ftill deftitute of motion in its limbs. This it enjoys, when it acquires the perfect form of the infect which it now reprefents.

a a, The two eyes in the head.

b, The teeth.

c c, The horns, which are folded near the legs upon the breaft.

d d, The firft pair of legs folded under the horns.

e e, The fecond pair, confpicuous under the firft.

f f, The third pair, which are laid on the belly.

It is likewife feen in what manner, all the ftrong joints of thefe fix legs are laid on the breaft between the horns.

g, The annuli or rings of the abdomen, together with the margin or border on each fide. But this is more manifeft in the fourth figure, wherein that margin or verge, as well as the little fwellings of the loins, are more diftinctly exhibited, and at the fame time it is feen how the body is all folded up and bent.

The creature in this form is, as I have obferved before, the real Nymph of the third order, according to the firft fpecies or method of transformation, which clearly and diftinctly exhibits all its parts and limbs without exception, fo that all thofe parts may be feen in it, which are afterwards found in the common labouring Ant, whofe Nymph it now properly is. This Nymph is therefore the Ant, and the Ant is a Nymph, but the Ant hitherto lies as it were hid under a peculiar difpofition of its limbs; and this is the principal difference.

When this Vermicle or little creature caft its skin for the laft time, then all its limbs and parts are very white like curdled milk, and are fluid as water; fo that under this form it ought to be confidered as if it lay yet in its egg, fince it is there difpofed in the very fame manner, and is as properly a Nymph. The only difference is, that in the egg its limbs, though certainly exiftent, are not vifible; though on the contrary they manifeftly appear, when it is a fecond time reduced to this condition, fo like that of an egg. Hence this little creature is twice, as it were, a fœtus, twice in its egg-ftate, and twice hatched or born. But the life it leads is not in all its circumftances the fame; it differs indeed very much, for it appears in the firft ftate like a poor and miferable Worm; but the fecond time, which is in fome meafure its renewal and regeneration, it is formed into a perfect creature. This procefs is formed in fo remarkable a manner in Butterflies, that we fee therein the refurrection painted before our eyes, and exemplified fo as to be examined by our hands; hence the Italian poet faid moft truly,

> Non v'accorgete voi, che noi fiam vermi,
> Nati a formar l'angelica Farfalla.

That is,

> Doft thou not know we Worms are born,
> Angelic Butterflies to form?

We muft further obferve, that the writers of natural hiftory ancient and modern, Ariftotle, Mouffet, Harvey and others, who have called this change in the Aurelia an egg, have not wandered entirely out of the path of reafon, provided their words be taken in the fenfe now mentioned. I would however have it obferved, that they muft be faid to have really deviated from the truth, in that they have not annexed the fignification mentioned in this place to their Aurelian egg, but have propofed it as a real and fimple egg, without any refpect to the effential parts. This cannot totally be overlooked by thofe, who labour cautioufly to inveftigate the natural changes in the infect tribe.

The head, the breaft, the belly, and the reft of the parts of this infect are invefted with a thin kind of membrane, and are fo very clofely furrounded by it on every fide, that even the extremity of the eyes, horns, teeth, and legs, are enclofed in it, together with the reft. However thefe lie in a loofe manner over each other, nor are they united or connected to one another by an uniform cutaneous cruft, as is the cafe in a particular manner in Butterflies. The membrane, which enclofes the parts of the Nymph of the Ant is not every where of equal thicknefs, indeed leaft of all where the limbs are clofe or applied to the body near the breaft; but where they are not fo clofely laid together, as in the extremities of the legs and horns, there the invefting membrane is equally thick in all its parts. This is very feldom obferved in the Aurelia, nor have I ever feen more than one example thereof in the Chryfalis of the fwift Butterfly, the trunk of which is in part diftant from the body; for there the invefting membrane is obferved to be every where equally thick, as may be feen among the figures of the Rhinoceros Beetles, in Tab. XXIX. But this is uncommon in Chryfallides, though it is conftantly the cafe in Nymphs.

Paffing thefe confiderations over, it is manifeftly evident from hence, that between the limbs, which are feen and reprefented in the Ant's Nymph, and thofe which appear in the Ant itfelf, there is no other difference, than that the appearance of the parts is fomewhat more evident and plain in the Ant, but in the Nymph fomewhat obfcure. We muft obferve that the fame thing holds equally in the Ant's Vermicle or Worm, which hides the limbs and parts under the skin that is not yet caft off. For in reality the egg, Worm, Nymph, and Ant, are all but one and the fame creature varioufly cloathed, and lying under different yet accidental forms. Therefore the Ant, that I may exprefs the bufinefs with fufficient accuracy, is covered or furrounded in the beginning, when it is an egg, with an oval or fpheroidal skin; and afterwards, when it appears under the form of a Vermicle or Worm, is covered with an annular and hairy skin; and thirdly, when it is a Nymph, and is found wrapped up in a divided and articulated veil; until, fourthly, it at length cafts this skin, and afterwards retains this its laft form, wherein it is a perfect infect, ftript of all its integuments; is ftill the fame Ant, in this variety of appearances: fo that having thus, at certain diftances and ftated times, caft off all thefe coverings, the creature is perfect, and is never changed more. This muft be in the fame manner underftood of all other Vermicles or Worms which have no legs; nay, of thofe alfo which have legs, that is, of fuch as fo long and fo often change their skin, until at length they no longer change their form, but become perfect infects, afterwards procreating their fpecies in the fame order.

When this Nymph cafts its laft skin, many remarkable changes are obferved; the eyes are altered in the head by a flow accretion, and change colour from white to black; the horns, the legs, and the reft of the body; are more and more difcoloured; a fuperfluous moifture is exhaled from all the parts, the limbs, which were till now without ftrength and motion, begin to move, and at laft the invefting skin is difengaged from all thofe parts; and then, and not before, this Nymph is called an Ant.

Fig. vii.

In this figure the Ant is reprefented under that form in which it fhews itfelf when it has caft the laft skin. All the obftacles which impeded the fight in examining its parts, are now removed. Hence we may fee the Ant no longer covered or veiled but in its real form; nor is it after this laft operation, during its whole life, further augmented or changed; as it has attained its full maturity and the greateft ftrength of life. The fame thing likewife is found in the fame manner in all other infects fubject to thefe changes, for none of them are ever increafed or changed, after having caft the laft skin. Hence, doubtlefs, the reafon may be affigned, why we fee thefe infects never become larger in other countries than in our own, unlefs they are of a different fpecies; or are fuch as eat fomewhat more plentifully, while they are in the form of Worms and Caterpillars; for by this means their bodies may become fomething, though not much, larger than ufual, as we have fhewn elfewhere.

By the power of infenfible perfpiration, the Ant's skin after all thefe changes is grown very hard, and becomes as it were horny, though it was fome weeks before the laft transformation, tender and fluid like water, fo that the creature could not ftir one of its parts with even the leaft motion. In the more confpicuous, that is, in the larger Nymphs belonging to larger infects, this change is ftill more confiderable than in the Ant's Nymph: for their fkin which was in the beginning of the change likewife very foft and tender, becomes in a few days horny and as it were bony, as fhall be hereafter explained in its proper place in the Nymph of the nofe-horn Beetle, which likewife belongs to this order.

It will be now proper that we exhibit in figures the limbs and parts of the Ant, in the fame manner in the Ant itfelf, as we have before fhewed them in its Nymph. To this purpofe I have allotted this feventh figure, wherein I reprefent the common labouring Ant, fuch as is ufually found in the gardens and paftures all over Holland and elfewhere. I here delineate the Ant magnified in fuch a manner, as it very cautioufly carries the Worm or Vermicle in its mouth, or between its two teeth, without the leaft danger of hurting it, Tab. XVI. fig. vii. *a*. Thefe teeth of which the Ant has only two, are more properly jaws, an upper and a lower, which hang crooked or bent on the outfide of the mouth, and have feven ferrated incifions or divifions, ferving as fo many particular teeth. This may be clearly feen in Tab. XVI. fig. xi. at the letter *a*. Moreover, the divifions of the head, breaft and belly may be diftinguifhed in this ftate much more accurately than in the Nymph. The eyes are very black, Tab. XVI. fig. vii. *b b*, the antennæ or horns under the eyes are of a faint red colour *c c*, and are compofed of twelve horny joints; the firft of which, that immediately under the eyes, is very long: but all thefe joints are covered or furrounded by briftly hairs. It is likewife fhewn very diftinctly here what form and ftructure the head and thorax are of, and that they are invefted with a horny, ftriated or furrowed, crooked, and indented fkin. This fkin refembles the fibrous joints of the wild pines, when they are cleaved or cut, where it is knotty. The conftruction of this furrowed fkin is feen yet plainer in the Ant exhibited in fig. xi. The incifions of the thorax, fig. vii. *d*, are divided into fix fharp-pointed prominences, which become more confpicuous backwards towards the loins. The loins themfelves confift of three knotty vertebræ or joints *e*, and are every where fet thick with briftly hairs. Underneath at the thorax are feen ftrong hairy legs *f f*, each compofed of four joints; the laft of which, or that properly called the foot, is divided again into fmaller joints, and the laft of thefe is armed with two claws.

The abdomen or belly, the colour whereof is fomewhat more red than the reft of the body; this being of a light red, fhines like a looking-glafs, and is furrounded with briftly hairs *g*. I call this creature I have been defcribing the working Ant; nor do I think it is pro-

provided with either male or female organs, as I ſhall demonſtrate to be the caſe in the Bees; ſince it ſeems to be deſigned by the moſt wiſe Creator for labour only, and to carry, remove, preſerve and nouriſh the young of the others.

FIG. VIII.

To make this hiſtory of the Ant as complete as in my power, I have here likewiſe delineated the male Ant in its natural ſize.

FIG. IX.

I delineate the ſame magnified in this figure, both becauſe the limbs of this creature may be the more conveniently deſcribed, and that the differences as well as agreements between one Ant and another may be the clearer or more evidently explained.

It appears then that the teeth *a* and antennæ or horns *cc*, are in this, in every reſpect, like thoſe of the working Ant; only that the teeth in the males are ſomewhat leſs than in the working kind: and this is likewiſe obſerved in the female Ant. Something like this is alſo ſeen in the teeth of male Bees. The eyes in the male Ant are much larger *bb*, and ſurpaſs thoſe of the working and female Ant; and this holds likewiſe in the males of Bees, Ephemeri, and other inſects.

Beſides theſe, three points or dots like mother of pearl are in this ſeen in the head; which I have likewiſe obſerved in Bees and Flies. They are indeed remarkable eyes of a diſtinct kind from the others, and make a peculiar difference between this male and the working Ant: but there is ſtill a greater difference in reſpect to the breaſt, for beſides that it is in this diſpoſed and painted in a quite different manner, there are alſo four wings *dd* very conſpicuous on it, whereof the two firſt are nearly twice as large and ſtrong as the two hinder ones. The ſtructure of the loins *e* and belly *f* is likewiſe very different from that of the working Ants: and the whole body of the male is larger, and of a darker colour; as is likewiſe the caſe in the males of Bees.

Theſe males of the Ants, which differ in reſpect to their Nymphs from the two other kinds, the latter having their wings regularly diſpoſed and folded, are not to be found at all times of the year among the ſwarms: hence it is probable that the working Ants kill them, when the buſineſs of generation is performed. The Bees we know act in this manner by their males, which are called drones. And this is probably the reaſon why the males are ſo frequently ill treated by the working Ants, as I have often ſeen.

Theſe males of the Ants regard nothing but generation, and therefore are admitted into that republic only for this ſingle purpoſe, to propagate their ſpecies. The ſame thing exactly happens among Bees, with whom the Ants have indeed many things in common; there is no ſuperiority or pre-eminence among either Bees or Ants; love and unanimity, more powerful than puniſhment or death itſelf, preſide there, and all live together in the ſame manner as the primitive chriſtians anciently did, who were connected by fraternal love, and had all things in common.

FIG. X.

I here exhibit the female Ant in its natural ſize.

FIG. XI.

The female Ant is here again repreſented magnified. She is naturally not only longer than the working Ants and males, but alſo much more bulky and corpulent: it is eaſy to diſcover by diſſection very ſmall, white, oval eggs in her. She has likewiſe teeth *a*, eyes *bb*, and horns *cc* like the former; and in the hinder part of the head towards the neck, ſhe is furniſhed alſo with three ſmall eyes, like mother of pearl; ſo that in this reſpect, the female remarkably differs from the working Ant, and is partaker of the privileges and benefis of the male. The female Ant is likewiſe diſtinguiſhed from the two former kinds, in reſpect to the ſtructure and form of the thorax *d*; this part in her being ſomewhat browner than that of the working Ant, and ſomewhat redder than that of the male. There is ſcarce any difference in the legs *ee*, or in the feet *f*, nor about the belly *g*, only that this is larger becauſe of the eggs that are to be lodged therein: all this is evident in the figures. Whether all the ſpecies of Ants are ſo conſtituted as to have in each community a great many working ones, ſome males and ſome females, I cannot of a certainty affirm. I am however poſitive, from my own obſervations, that this is the caſe in the moſt common ſpecies of Ants, which are found in the fields and vineyards in Holland and about Amſterdam; for I have there frequently taken them out of the ground, and from among the roots of the graſs, and brought them to my chamber and kept them alive by proper food to complete my obſervations.

To do this I uſed the following method: I provided a large deep earthen veſſel, and about ſix inches from the brim or verge of it, I put a bank or artificial rim of wax, and then on the outſide of the circumference of this I poured water, in order to prevent the Ants confined in this encloſure from getting out. I afterwards filled the cavity of this diſh with earth, and therein placed my little republic of Ants. It happened that in a few days the Ants laid their eggs in this veſſel: from which were produced thoſe Vermicles or Worms, erroneouſly called by the vulgar, eggs, which I have before deſcribed. It cannot indeed be expreſſed in words, with what induſtry and ſolicitude theſe working

Ants take care of the young ones, and with what love they feed them: they carry them with amazing fondneſs between their jaws from place to place, nor do they omit any thing neceſſary for their ſupport or nouriſhment.

When the earth wherein they lived grew dry, I obſerved that they carried their young ones to a lower part and deeper under the ſurface; but when I poured a little water thereon, ſo that the mould became moiſt, it was then wonderful to ſee how they all, ſtimulated with love, endeavoured as much as they could to take away their young and carry them to a dry place. Nay, I obſerved that after I had poured in a greater quantity of water, they with all their might carried them to the higheſt part of all. If I only moiſtened the dry earth, then they likewiſe carried their young out of the damp part. Thus I had opportunities to ſee very diſtinctly, that the young ones moved and ſucked nouriſhment out of the fine and ſmall particles of the earth.

I often endeavoured to nouriſh theſe young Worms, without the aſſiſtance of the working Ants, but I never ſucceeded. Nay, I could not exclude even the Nymph of thoſe Vermicles, which the Ants likewiſe carry daily from place to place, without the aſſiſtance of the working Ants. I gave them ſugar, raiſins, apples, pears, and the fruit of other trees and plants. I never found that they built thoſe artificial neſts mentioned by ſome authors, and therefore I apprehend that is to be underſtood of ſome other ſpecies. Even in thoſe places which they ſpontaneouſly inhabited, I never diſcovered any work of art performed by the Ants of this ſpecies; only broad paſſages and crooked ways, deſigned for carrying their young from one place to another. I have obſerved likewiſe that they follow the ſun's motion, and convey their young according to the courſe that luminary purſues: this I have obſerved in the fields where they inhabit little hillocks of earth; for they there carried their young conſtantly to thoſe parts where the ground was warmed with the ſun's rays. I never obſerved that Ants provide themſelves any food for the winter, although this has been ſo ſtrongly aſſerted: and therefore I think they eat nothing whilſt the winter is ſevere; as is common with many inſects, and in particular with ſome ſpecies of Bees, which in the midſt of winter abſtain from all kinds of food *.

Of certain other kinds of Ants, ſome of which ſpin like the Silk-worms.

BESIDES the ſpecies of Ants hitherto deſcribed, I have ſeen five other kinds, ſome of which I preſerve in my collection. The firſt ſpecies is very large, and was brought from the Cape of Good Hope. I have delineated it in Tab. XVI. fig. XVI. of its natural ſize. Its head, eyes, horns, teeth, breaſt, legs and belly are ſeen there as they naturally are. It is of a bright red colour: but whether this was the working Ant or the female of that ſpecies, I could not diſcern: as it had no wings I am certain it was not a male. I am likewiſe ignorant of the diſpoſition and nature of this ſpecies of Ants.

The other ſpecies of Ants, which I have ſeen in Holland, is fleſh coloured, and of ſuch ſize and form as is expreſſed in fig. XIV; but I cannot now determine whether this was a working Ant or a female. I met with this ſpecies at Honteſlard; where I examined in a wooden bole its eggs, Vermicles, Nymphs, working Ants, females and males, in great numbers mixed together in ſome mould, where they were ſet in order to ſerve ſome birds for food. The males exceeded ſomewhat in bigneſs the Ant I expreſſed in the figure, and had four membranaceous wings. But what deſerved particular notice in this ſpecies was, that the Nymphs were all encloſed in a ſheath or caſe, which, when the working Ants carefully preſerved, carried here and there between their jaws, made a very agreeable figure; for thoſe Ants carried on this occaſion a bag bigger than themſelves. I experienced then for the firſt time that the Vermicles of Ants, as well as the Silk-worms, form a bag or follicle, and that thoſe that are encloſed in it are changed into Nymphs. This web was of an oblong oval figure, and wrought with delicate and fine threads about the body, being of a ruſty iron-colour, and when I opened it, I found a Nymph in the inſide. I likewiſe carried ſome of theſe encloſed Nymphs with me to Amſterdam, which after ſome days gnawed their way out of their webs, and produced ſome male Ants: this happened on the eighteenth of July. I gave the figure of ſuch a ſheath or caſe entire, and in its natural ſize in figure XII. and a ſection thereof in fig. XIII.

The third ſpecies of Ants that I obſerved, was ſomewhat leſs than the common Holland Ant: this does not ſpin. I have given the hiſtory thereof at large. Its body was much blacker and brighter than any of the other

* Our author is not ſingle in his opinion that Ants do not eat in winter; Leewenhoeck appears to be of the ſame mind, and imagines that they ſpend that ſeaſon, like Dormice and many other ſorts of animals, in a ſtate of ſleep; and this ſeems to be reaſonable, as Ants are obſerved to move more ſlowly as the cold weather advances. Mr. Gould alſo agrees with Swammerdam that the Ants do not make any proviſion for winter. But though our author here did not obſerve any ſuch proviſion to be made by thoſe he examined, yet probably ſome other ſpecies may, and other naturaliſts tells us very wonderful things on this ſubject; and further, this opinion of their providing for winter ſeems to be countenanced by the royal and inſpired naturaliſt, Prov. vi. 6, 7, 8. However, if it be true that they remain in a ſtate of reſt during the winter, the proviſion they make may be for their young, for whom their affection is wonderfully remarkable.

ſpecies. I found theſe Ants running on ſome willow-trees, and they ſeemed to live only there. But I have not been hitherto able to ſee their males.

The fourth ſpecies was again leſs, but of a thicker and more reddiſh body; nor have I ever found its males. The fifth ſpecies was of a more ſlender, and at the ſame time ſomewhat longer body than the fourth: I ſaw the males of this with four wings. The ſixth ſpecies that I obſerved was wonderfully ſmall; it was of a bright red colour, had two eyes, two horns, two jaws, and ſix legs; and it was, like the reſt, divided regularly into a head, thorax, and belly. I have not yet ſeen the males of this ſpecies; and therefore I only repreſent the working Ant belonging to it in its natural ſize in figure XV. Theſe little Ants are ſeen only about the middle of the month of July; but then ſome hundreds appeared, and they yearly at ſtated times infeſted the cheeſe-loft and pantry, notwithſtanding all our endeavours to drive them away. After October not one of them was to be ſeen until the next year. It ſeemed to us that they came out of a wine-cellar, and crept through the ſmall clefts between the beams and timber planks to the place where they could find food. This, which was firſt conjecture, we afterwards found to be true; for when the cellar had been kept full of water for ſome months, we never afterwards perceived any Ants.

What merits particular regard in this hiſtory is, that theſe Ants remained ſo long as to the middle of July in the earth and ſand, and then firſt came in ſight; but after October all of them betook themſelves again to their little cells. Whether they lived in the mean time without food, or whether, as is common with many inſects, the old ones died, and young ones were produced out of the remaining eggs and Nymphs, I cannot determine: but from the analogy of other inſects I can eaſily judge that the manner of theſe creatures living was very ſingular and uncommon. Beſides, it is probable that the males of theſe Ants were deſtitute of wings, ſince I have for ſome years made my obſervations on them, but could never find any whatſoever that had wings. I would not, however, aver this for truth; becauſe nature is wonderfully conſiſtent with herſelf in all her works. Dr. Padbrugge has informed me that he alſo obſerved many ſpecies of Ants in the Eaſt-Indies; and particularly that there were white Ants there, leſs than the common Dutch ones; and that they were very deſtructive of food and ſome kinds of merchandiſe. I have this year received from the ſame gentleman a very beautiful figure of the black ſpotted red Ant, which he ſent me from the iſland of Ternate: it is ſomewhat leſs than the Ant of the ſecond ſpecies which I have deſcribed above. The largeſt Ants this gentleman has obſerved he aſſures me were as long as the firſt joint of the thumb; and their neſts were ſix feet long in circumference and were divided into various particular cells: theſe places of reception were ſometimes all found under the earth, and ſometimes moſtly prominent above the ſurface; but they were always framed with an amazing art. I cannot determine how this matter is, for Ants make no neſts here: it is enough for me to give a faithful relation of what I have been informed, and particularly to recommend the authority of this curious gentleman. He likewiſe ſent me the figure of a Frog with that of the red Ant; its hinder legs are cloven, which is very uncommon, and probable the caſe only in Frogs that live on dry land. This will be rendered more certain by accurate reſearches.

The very curious hiſtory of the Naſicornis, or Rhinoceros, or horned Beetle, illuſtrated with accurate figures.

INTRODUCTION.

"WE admire the ſhoulders of Elephants "that carry towers; the necks of "Bulls, and the furious toſſes from their horns; "the ravages of Tigers, and the manes of "Lions: but we ſhould know that nature is "no where more complete and perfect than "in the ſmalleſt objects." This is a very juſt ſentence pronounced by Pliny in his far diſtant age, though the wonderful works of nature were at that time but obſcurely known. We ſhould therefore, ſurely, endeavour to ſearch into nature near at hand, and where ſhe is conſpicuous in the moſt minute things, or her miracles will never be diſcovered. Then will it be made clearer than the ſun at noon, that as many natural myſteries are hidden in the narrow compaſs of the moſt vile and contemptible of animals, as in the vaſt viſcera of the largeſt. In order to elucidate the incomprehenſible power of nature, it muſt be inveſtigated in the ſmalleſt creatures. Nor let the extreme minuteneſs obſerved in theſe, deter any from the inquiry; it ſhould rather encourage us to be more diligent: for the leſs the work of nature is, the greater and more magnificent it afterwards ſhews itſelf in thoſe at firſt inviſible parts, and exhibits to our ſight and touch all thoſe things which before eluded our ſenſes, and our moſt acute intellectual faculties. The greatneſs and majeſty of God are conſpicuous only in the works framed by his infinite power. But as our eyes are not ſufficiently

ſufficiently acute to view theſe things perfectly, it is neceſſary to invent and find out all kinds of aſſiſtances and artificial contrivances proper for aſſiſting the ſight, by the help of which theſe things may be diſtinctly ſeen. By this means, and no other, we can attain to know with what order, meaſure, rule and wiſdom God's creatures are all formed, and how they depreciate all the work of human art and induſtry, the latter not being able to bear too near an inſpection. The beſt of them only expreſs the external ornaments, wherewith the ſurface as it were of God's works are covered; and they are therefore deſtitute of that true food of the mind, wherewith the works of God abound. The more accurately theſe are examined, and the more perfectly they are explained, the more wonderful, lovely, and adorable they always proclaim their Creator. Though many works of art, which derive their powers from nature and the effects of regular motions, perform wonderful things; yet when they are more intimately examined and inveſtigated, they immediately betray the imperfect condition of the artificer. Therefore all the maſterly touches of Apelles, compared to the very refined lines of nature, are only rude, unpoliſhed and coarſe; and all the ſplendor of tapeſtry finiſhed by human art vaniſhes, when only one of nature's works contained in a ſingle pulmonary tube of an inſect is produced: who can delineate even this, the leaſt of theſe wonders, with adequate dignity? what genius is able to deſcribe, or what induſtry can inveſtigate it? our eyes and fingers, and all the powers of our underſtanding are deficient in this reſpect, as will be evident from what I ſhall preſently ſhew concerning the lungs of the Rhinoceros or noſe-horned Beetle; and thus it will be at the ſame time moſt ſtrongly demonſtrated, that the works of God are moſt wonderful in the ſmalleſt objects. Thus I conclude this introduction, crying out with the royal prophet: "I praiſe "thee, becauſe in beholding thy works I am "tranſported with admiration: I celebrate thy "wonderful works when my mind is moſt "enlightened."

Though I ſhall attempt in the following pages to deſcribe to the praiſe and glory of the ſupreme being, the whole change, or, if I may ſo call it, the tranſcretion of the noſe-horned Beetle, conſecrated of old to Mercury, and expoſe to public view its origin, life and propagation; yet I would not have any one think, that I intend to give its accurate and perfect hiſtory. As I happened to be diſſecting one of theſe Beetles in July laſt year, in the preſence of the very learned and experienced phyſician Dr. Matthew Slade, I diſcovered the wonderful conſtruction of its general parts. I was thence led to examine into its origin, and made a diſſection of the Worm out of which it is produced. This having been the occaſion of the hiſtory that I ſhall here exhibit, it will contain no more than an accurate narrative of thoſe things, which I then and afterwards remarked in regard both to the internal and external parts of this inſect. But if God gives me health and leiſure, I ſhall probably at ſome other time proſecute this ſubject much further, though what I now advance is ſufficient to ſatisfy the moſt curious adorers of divine miracles, being of the greateſt importance and moſt wonderful dignity.

C H A P. I.

Of the places wherein theſe Beetles live: of their generation, eggs, Worms and food; how long they are feeding; with varous other uncommon incidents.

As to the places wherein the Rhinoceros or noſe-horned Beetles commonly live, they are moſt uſually our docks and yards, where they lie among the chips and ſaw-duſt, and in the aſhes of reeds which are burned in tarring of ſhips, and among the rubbiſh of kitchen gardens; in the remains of the ſumach wherewith leather has been tanned; as alſo about old trees, and in rotten wood.

Theſe Beetles generate in the months of June and July; the male, Tab. XVII. fig. I. alone has that remarkable horn on his noſe, whence the ſpecies is named noſe-horned; the female is ſomewhat larger, fig. II. the male gets upon the female, and with the horny or bony part of its penis, as with two crooked claws, fixes himſelf upon the horny or bony part, which conſtitutes the vulva of the female; by this means the female cannot eſcape, and the male in this manner injects his ſperm, which it has in great quantity, and ſo impregnates the female. In the ſame manner the male Butterfly of the Silkworms holds its female faſt by the aſſiſtance of two crooked and horny claws, fixing himſelf on the horny or bony ring, in the hinder part of the female's body, and by this means engenders with her, as not being then able to get away from him. The males are ſo very violent on this occaſion, that they will fix themſelves to the females after they are dead; and they are hooked ſo ſtrongly together, that you may tear them to pieces eaſier than ſeparate them.

After coition the female Beetles in this ſpecies penetrate deeper into the wood or other matter; they inhabit and lay their eggs there, not in heaps but ſcatteredly and at diſtances. The annexed figure III. exhibits the magnitude of theſe eggs, though ſome of them *a* are often obſerved to be greater than others *b*, as one

one female is larger than another. The egg is of an oblong round figure, and of a white colour, and has a thin, tender, membranaceous, flexible and foft coat or fhell; it contracts very eafily with air, and corrugates or wrinkles up when the moifture evaporates; the fame thing happens in Hens eggs when they have not the hard or outer fhell. It is difficult to fay in what fpace of time thefe eggs ought to be hatched by the mere force of the fun and heat; but about the end of Auguft we always find the young Worms or Vermicles, fig. IV. which have come from thefe eggs. If one of thefe little eggs be dexteroufly opened with a fmall pair of fciffors, a tenaceous and whitifh moifture flows from it. The firft, and indeed a very rare, change that I obferved in thefe eggs, exhibited two perfpicuous ruddy points, which were tranfparent through the coat of the egg, and were likewife furrounded on each fide; with fome other fpots of the fame kind. I obferved indeed afterwards, that the two former were the teeth of the Worm yet enclofed in the egg; and that the lateral points were the apertures of the pulmonary pipes. It is extremely worthy of regard how hard the teeth of this Worm are, even in the egg; fo that this infect, whofe teeth attain their perfection before all the other parts, is able as foon as it comes to the light to feed itfelf, and by gnawing and devouring the wood wherein it is placed to nourifh itfelf. The manner in which this Worm is difpofed within the fhell of the egg, likewife deferves great confideration; it lies there folded up, fo that its fundament is between its teeth, and the latter reft on the former. The body being thus folded up, the legs are very curioufly difpofed on each fide at the verge of the belly, and one may fee that their claws infenfibly acquire a colour, and become ftronger through the coat of the egg. The Worm itfelf, in due time, breaks open the fhell of its egg in the fame manner as a chicken, and creeps therefrom to the next piece of wood or other fubftance. The Worm *, when thus frefh excluded, fig. IV. is very white; it has fix legs, and a corrugated or wrinkled body covered on all parts with hair; but its head is then bigger than its whole body, which is a very wonderful thing, and indeed holds likewife in other creatures in fome degree, not excepting even the human fpecies. As the head of this Worm is horny or bony and extremely hard, the all wife-Creator therefore forms it firft, left the other fofter and more humid parts, which therefore increafe fafter than the bone, fhould precede it in growth; and thus has contrived that all the parts fhould attain their determinate fize and due form at the fame time; and therefore the moft wife providence of God here again becomes obvious to our fenfes. The colour of the head becomes by degrees yellowifh, and after this fomewhat red, until it is at length changed into a brownifh red. This Vermicle or Worm has two teeth or jaws, the tops of which are likewife cut and divided into fmaller teeth. Thefe teeth deferve particular confideration, becaufe they are fo large and ftrong, that one may certainly very properly call them jaws. They may however be much more diftinctly feen in the Vermicle or Worm, whilft it is ftill white and lies in its egg, than when it has been for fome time out of the fhell and is grown bigger.

If one views thefe eggs from time to time with great care, whilft the Worm ftill lies in them, the heart beating on the back prefents itfelf to view. If the fame eggs be then opened, they exhibit, befides the outmoft coat or fhell, on the inner part, fome other fibrous and membranaceous little parts, and two very fingular ones on each fide, fituated where the legs are placed, towards which are detached a great many white little fibres. Thefe little parts are like thofe umbilici or marks at which Peafe and Beans are fixed to the pods. But this fimilarity does not hold in refpect to the office of nutrition, fince there is no fuch thing in eggs, for they carry their nourifhment enclofed within them.

Among all the eggs of infects, of which I have various fpecies in my collection, I know none worthy of greater attention than thofe of Earth-Worms, for thefe infects have a red blood in their veffels, which, whilft the Worm ftill lies in its egg, may be obferved to move, and is wonderfully carried about in the heart itfelf. This is the reafon why I take the prefent occafion to mention this fingular phenomenon; though the egg of the Earth-Worm is not larger than that of the Rhinoceros-Beetle, yet the former creeps out of it in form of a Serpent, and is many times as long as it appeared to be in the egg. I faw two fpecies of thefe eggs, of different fizes, and of an oblong roundifh figure, uniting on each fide in a prominent point, and therefore one would be inclined to fay that this microcofm or little world had two poles, and that one may hope to difcover a great many wonders therein. They are of a pale yellow colour, and have a tinge of green. In the fpring thefe eggs are found difperfed here and there in the earth. In order to hatch them properly, I put them into a difh, and covered them with white paper which I always kept wet. If any perfon does this carefully in his chamber every day, he may very eafily difcover thefe wonders. In the fame manner I have alfo hatched the eggs of Snails. I have likewife two eggs as big as thofe of the nofe-horned Beetle, but covered with a perfectly hard fhell like a Hen's egg, which is indeed very rare.

* To the Beetle kind we are to look for that deftructive infect mentioned in the fcripture by the name of Kankerworm, and coupled with the Locuft for its devouring nature. The common mealy Beetle which flies in the evenings about hedges, and which children play with, calling it the Miller Cockchaffer or Dor, is common to the Eaft as well as Europe, and is probably in its Worm ftate the creature meant in thofe paffages. The Worm hatched from the egg of this Beetle lives under the furface of the earth, and feeds upon the roots of corn. A few years fince it almoft created a famine in fome parts of England.

Whoever would preserve these and such kind of eggs must pierce them with a very fine needle, press out the contained humours, and having afterwards blown them up with a small glass tube, he must fill them with a little rosin dissolved in oil of spike. I have now some eggs taken out of the ovary of the human species and kept in this manner. These I discovered in the year 1666, and from hence I began to suspect that I should have found eggs in all other animals; nor was my reasoning in this point without its foundation.

Let us proceed in the history of this insect. As soon as the Vermicle or Worm of the nose-horned Beetle has crept out of its egg, it immediately finds its food ready prepared for it; that is an old tree growing rotten, or the remains of the sumach, for in those the egg is deposited by the mother Beetle. Nor does she afterwards take any further care of her egg or of the Vermicle; this creature therefore, though much less in bulk, resembles the tall Ostrich, whereof the inspired writer says, Job xxxix. 14, 15, 16, 17; "Which leaveth her "eggs in the earth, and warmeth them in the "dust, and forgetteth that the foot may crush "them, or that the wild beasts may break "them. She is hardened against her young "ones, as though they were not hers, her "labour is in vain without fear: because "God hath deprived her of wisdom, neither "hath he imparted to her understanding." Many are also of this disposition, though some of them take great pains to deposit their young among proper nourishment. However negligent and careless this Rhinoceros-Beetle may be in providing for her issue, yet we observe in others a much more admirable innate sense or instinct, by which they maintain and bring up their young after they are out of the egg. Do not the laborious Ants and careful Bees teach this lesson? the latter daily nourishing their offspring with banquets of the purest honey.

Other insects enclose their young or eggs in rotten trees, as the celebrated Redi well observed. Some again hide their future progeny in the shoots of fruits and plants, which for this purpose they first pierce with sharp instruments, given them by God for that purpose: lastly, others leave or place their issue in the bodies of living animals, or in other inaccessible places, in order to find natural nourishment ready as soon as they are out of the egg, for it is not allowed them by nature to take any further concern about their progeny.

To this place might be likewise properly referred those particular observations which I have made on the excrescences of oaks and other trees and plants. But since we shall professedly treat of these hereafter in their proper place, we shall remit the reader thither, and now rather prosecute the history of the Rhinoceros-Beetle.

How long the Vermicle of this Beetle is in nourishing, until it acquires a strength proper for undergoing its change, I cannot easily determine: for some years before I knew that this singular creature was produced from those Worms, I kept them above a year in the remains of sumach and earth in a glass bottle, and during all that time observed no change in them. I have likewise, not long since, kept such a Worm a whole year in the same sumach wherein I found it, without wetting it; however much this moisture may be requisite and necessary to sustain the life of these Worms, this I mention only to shew the strength of their life *. And hence I also conclude, that if this Worm can live for a whole year, after being come to its full growth, surely the younger Vermicles or Worms that are not yet grown to perfection, must take some years to their increase, before they attain this state: and it is certainly an admirable thing, that even the Worm out of which the Ephemerus before described is produced, should require three years before it attains its change, though its appearance under this last form does not continue above five hours: this may be seen at large in the preceding history of the Ephemerus.

C H A P. II.

The name of the Worm out of which the Rhinoceros-Beetle is produced; also its external parts, disposition and motions. That it loves heat, and that it casts a skin; with other incidents tending to illustrate this subject.

THE Worm I have been hitherto speaking of, is described by Mouffet and other authors, under the name of Cossus, and is, when it is arrived to its full growth, half an inch thick and two inches long, and of a white colour; its body is very deeply wrinkled, Tab. XXVII. fig. v. *a*, and is divided in a beautiful manner into folds or plaits. The whole body is composed of annular incisions common to insects, and to which authors give the name of annuli or rings; this denomination, however, does not seem so proper, when these annuli or rings are not composed of a horny or bony matter, as is the case in many beside these. On each

* We have an account of the strength of the principle of life in the beetle recorded in the Philosophical Transactions, which is altogether surprising. Mr. Baker, a person of undoubted credit, kept one of these alive under a glass, without any food, two years and a half, and it then escaped by accident. He had first attempted to destroy it by drowning it in spirit of wine, but it revived after repeated trials of this kind, though in one of them it was kept in the spirit a whole night.

each ſide of this Worm are ſeen nine reddiſh points or ſpots *b*, not exactly round, but ſomewhat compreſſed like the ſeed of the kidney-bean. Theſe are the orifices of the pulmonary tubes, and hence I call them puncta reſpiratoria, or points of reſpiration. The firſt annular inciſion, which conſtitutes the head, has no point or mark of that kind: the ſecond exhibits the firſt aperture of the pulmonary tubes, over which there is likewiſe a coloured ſpot *c* in each ſide of the body. The third and fourth rings again have no ſuch ſpots or points, becauſe, as ſhall be afterwards explained, the ſheaths or caſes of the wings, and the wings themſelves, which the Beetle to be produced out of this Worm hides under theſe ſheaths, increaſe in proceſs of time in that part, and cannot be perforated. On account of thoſe ſheaths theſe inſects are called vaginipennia, or ſheath-winged. The fifth therefore and ſixth inciſions, and the reſt that follow in order behind theſe, to the number of twelve incluſive, have each their points of reſpiration. The head, which is of a bright red colour, and ſomewhat rough, has ſeveral diſtinct parts, eyes, horns *d*, and teeth *e e*, but the lip is ſplit in two parts, and is viſible among the teeth: above theſe are placed the antennæ or certain prickly and articulated hairs, which lie as it were under the skin; theſe are very uſeful when the Worm is feeding. In Locuſts likewiſe the ſame briſtly hairs are obſerved, but more conſpicuous, and they are of great uſe at the time the Locuſt changes its skin, and caſts it off from the claws, teeth and eyes. It is not difficult to keep the Locuſts alive, if raiſins are given them to eat; for if theſe are put on a thread one after another, and hung up in a wicker basket, the Locuſts will eat them even to the skin. The Coſſus has ſix ſmall legs *g*, three on each ſide of its body, of a yellowiſh red, furniſhed with claws and hair, divided into five joints, and placed at the ſecond, third, and fourth annular inciſions of the body, or the neareſt to the head. The other or hinder rings of the Worms ſhine like a looking-glaſs, the skin being there extended and very ſmooth. Hence the ſurface is there of a tranſparent blue, and under it are ſeen ſome of the air-pipes, Tab. XXVII. fig. V. *h*, of a ſilver colour, making a wonderfully elegant and beautiful appearance. The reſt of the skin terminated at the anus *i* is covered with fine and tender briſtly hairs *k k k*. The motions of this Worm are ſluggiſh, and all its actions heavy. Its greateſt ſtrength is in the head, breaſt and legs, for by the help of theſe, it immediately forms for itſelf another hole in the earth or other matter, whenever it is taken out of it. And when this happens, it bends its back very much, and gathers its belly as it were into a ſemicircular cavity, nearly in the ſame manner wherein I have delineated it.

It frequently happens, that the ſumach or wood wherein theſe Worms live, grows by a natural fermentation warm in the ſame manner as moiſt hay, and at length becomes very hot. The Coſſi do not regard that, for the warmer their habitation is, the better they live in it; they have at theſe times much better health, and are more brisk and lively than uſual, and if they are roughly touched, they are more quick and violent in defending themſelves by biting; though theſe Worms are not otherwiſe of a miſchievous diſpoſition, but on the contrary they are very gentle and mild.

Whilſt the Coſſus becomes inſenſibly bigger, it ſometimes changes its skin like the Silk-worm: but I have not yet learned from obſervation how often that happens. Before the Worm caſts its skin, it firſt, like Silk-worms, alſo diſcharges itſelf of all its excrements, and then bending its body, it makes a new hole in the earth, that it may be able to caſt its skin the more conveniently in a ſeparate habitation. Nothing in all nature is, in my opinion, a more wonderful ſight, than the change of skin in theſe and other the like Worms. This matter therefore deſerves the greateſt conſideration, and is worthy to be called a ſpecimen of nature's miracles; for it is not the external skin only that theſe Worms caſt, like Serpents, but the throat and a part of the ſtomach, and even the inward ſurface of the great gut, change their skin at the ſame time. But this is not the whole of theſe wonders, for at the ſame time ſome hundreds of pulmonary pipes within the body of the Worm, caſt alſo each its dilicate and tender skin. Theſe ſeveral skins are afterwards collected into eighteen thicker, and as it were compounded ropes, Tab. XXVII. fig. VI. *a a a a a a a a a*, nine on each ſide of the body, which, when the skin is caſt, ſlip gently and by degrees from within the body, through the eighteen apertures or orifices of the pulmonary tubes before deſcribed, having their tops or ends directed upwards towards the head. Two other branches alſo of the pulmonary pipes that are ſmaller, and have no points of reſpiration, caſt a skin likewiſe, *b b*. Moreover, each of the eighteen points or apertures of reſpiration are likewiſe obſerved to open and dilate their orifices at the ſame time. If any one ſeparates the caſt little ropes or congeries of the pulmonary pipes with a fine needle, he will very diſtinctly ſee the branches and ramifications *c c c c* of theſe ſeveral pipes, and alſo their annular compoſition. The skull is then likewiſe divided into three parts 1, 2, 3. Its middle part ſhews the teeth *d d*, which are renewed and the old ones thruſt out: in the middle of theſe is ſeen a lip *e*, and on each ſide there are prominent horns *f f*. Behind the lip may be ſeen the skull, terminating like a triangle in an acute point, on each ſide of which are ſeen the two other portions *g g* of the bone divided into three parts. The ſharp-pointed or prickly antennæ are likewiſe changed, and from the eyes themſelves is taken a tranſparent membrane. This happens likewiſe in Serpents when they caſt their skin. The exuviæ or caſt skin exhibits ſix apertures, wherein the legs *h* were fixed.: and the diviſions or wrinkles, and little depreſſions

depreſſions of the skin are ſtill plainly conſpicuous. Nay, on the hinder part *i*, where the skin is twiſted and complicated, whoever accurately examines the skin itſelf, may ſtill obſerve the coat that was caſt by the inteſtinum rectum. It is likewiſe remarkable, that the skull remains fixed to this caſt skin of the Coſſus; whereas the contrary happens in Silk-worms, whoſe skull always ſeparates from the caſt skin, except under the laſt change, when the Silk-worm is changed into an Aurelia or Chryſalis. The head and teeth of the Coſſus, having lately caſt their skin, grow white and become flexible and tender, though they are otherwiſe hard as horn, nay, as bone; inſomuch that when the Worm is provoked, it attempts to bite even iron. But what effect this change of the skin in the pulmonary pipes at length has in the Worm, will afterwards appear, when I ſhall at the ſame time ſhew more clearly, that there are more than eighteen principal branches of pulmonary pipes in the Coſſus, as is likewiſe the caſe in Silk-worms. This may be likewiſe exemplified in the Worm of the Hornet, which has twenty points of reſpiration. But I ſhall now proceed to the anatomy of the Coſſus.

CHAP. III.

The anatomy of the Coſſus. The manner in which it is to be killed. Its blood, heart, fat, pulmonary tubes, throat, ſtomach, ſpinal marrow, and the nervus recurrens. Whether the Coſſus is eatable. How it may be ſeaſoned or preſerved, with ſome uncommon obſervations.

I HAVE various contrivances to execute the diſſection of the Coſſus, according to the different ends I propoſed to myſelf in each diſſection; but that which I uſe moſt frequently for this purpoſe, is to kill the Worm in ſpirit of wine, or to ſuffocate it in rain water ſomewhat more than lukewarm: after ſome hours I take it out again, and thus it not only loſes all its motions, but its muſcular fibres are never afterwards contracted, which would otherwiſe very much incommode the diſſection.

When the skin is opened along the back, where the heart is placed, which is extended through the whole back, in form of an oblong canal, and appears about the loweſt rings in the manner of lymphatic veſſels; immediately after the blood, which is a watry humour or ichor, iſſues out at the wound, the moving fibres of the annuli or rings, Tab. XVII. fig. VII. come then in ſight. Theſe are indeed very wonderful to obſerve, and can ſcarce be well deſcribed, for they ſhoot over each other, from one ring to another, in a ſtraight, tranſverſe, oblique or decuſſated direction, and often join one another as by inoſculation. Some of them are longer, ſome thicker, and ſome ſmaller than others, as I have endeavoured to repreſent in ſome degree in the figure juſt now cited. But the muſcles are not ſo beautiful in any of the inſect kind as in Snails, as may be ſeen in their hiſtory, and the figures illuſtrating it.

All along the courſe of the heart in the Coſſus, ſimilar moving fibres are likewiſe placed, which are inſerted into the heart itſelf; and they, like ſo many different little ropes, expand and contract it. The external ſurface of the heart reſembles a membranous oblong tube, fig. VIII. *a*, which is very narrow *b* about the top, and is likewiſe contracted like a knot about the middle of the body, and widens again *c*, and at laſt is joined *d* very cloſely in the hinder part under the thirteenth ring. On each ſide of the heart are ſeen ſome blackiſh uneven points or ſpots, which render the heart, though tranſparent enough of itſelf, the more diſtinctly conſpicuous.

If the inciſion be afterwards made ſomewhat wider, the fat appears, conſiſting of innumerable, very ſmall, and as it were ſandy, fig. IX. globules, which, when viewed with a microſcope, ſeem to be again compoſed of innumerable and yet ſmaller particles, all which are ſupported by very thin and tranſparent membranes or coats, fig. X. *a a*, which are variouſly diſtributed through the body of the Worm, and with their number and diverſity very much obſtruct the ſight of the internal parts. If this fat be viewed with a microſcope, the pulmonary pipes *b b* appear to run up and down through it, and the fat itſelf is exhibited in form of minute, oily, globular particles *c c*, ſwimming between white, ſpherical, and membranaceous parts. But when the fat of the Coſſus is received into a ſmall glaſs, and placed on a burning coal, ſtill covered with its aſhes, then in roaſting there iſſues out of it an oily white ſubſtance in great abundance, which being put on paper has the ſame effect that oil has, and when thrown into the fire it burns very bright; and therefore from all theſe ſigns, I conclude it is of the true nature of fat. This fat is not of a regular but various figure in its diſpoſition, like certain pneumatic veſicles, which I ſhall hereafter delineate in the ſheaths or caſes of the wings. This, however, is to be underſtood only in reſpect to the diviſion of theſe tranſparent coats, whereby, as a foundation, the fat is ſupported, for the figure of the particles of the fat itſelf is commonly ſpherical. In the Silk-worms, whoſe fat is yellow, it appears of

a very

a very irregular form. When this fat of the Coffus is further examined, with the help of a powerful microfcope, it appears of an unfpotted whitenefs, and is covered or furrounded with tranfparent little bubbles, almoft like bladders: it is contained or enclofed in little membranes, and is a real oil or fluid fat; and hence therefore if thefe membranes be wounded a little with the point of a very fine needle, it eafily flows out, and a drop of it then falling into water, fwims on the furface like other fat. Whilft this fluid fat, difcharged in this manner, and the white membranous particles are breaking, the object in general is thereby darkened, and the water becomes muddy, as if there was ftarch, lime, or chalk mixed with it; becaufe the fat then divides itfelf into many little particles: but it is more beautiful to fee this in the Nymph than in the Worm. The fat of larger animals, viewed with a microfcope, is likewife obferved to confift of very minute particles; which, becaufe they are white, one would fay are like grains of fand; however, they are not fo tranfparent, and all of them feem to be almoft of the fame fize, which is not the cafe with refpect to fand. Therefore the globule compofed of fat ought not to be confidered otherwife than as a mafs of little grains of fand faftened together, though every particle of fat is contained in its diftinct membrane, all which break in pieces and fall to the bottom, when the fat is melted. In the firft rudiments of calves and fheep, in the wombs of their parent, thefe fmall particles of fat appear even to the naked eye, without a microfcope; for as there are not a great quantity of them there, they may be the more diftinctly obferved.

To proceed: as therefore the fat hinders much the view of the internal parts, this impediment is increafed by the addition of the pulmonary tubes or pipes, for they are diftributed through the Worm, in eighteen principal branches, in fo different and beautiful a manner as cannot be expreffed by words. Thefe branches proceeding from the points of refpiration, are afterwards divided into innumerable little fprouts and fhoots; fo that there is no part in the Worm, to which fome of thefe air-pipes or their ramifications are not extended. They are conveyed even to the mufcles, to the brain, to the nerves, whofe moft minute divifions are likewife provided with their air-pipes. Wherefore this Worm, as well as the other fpecies of infects, feem indeed to be fuftained much more by the power of a fubtile air, than the larger animals and thofe which moft abound with blood: unlefs one fhould be inclined to think that the air is mixed with the blood, by means of the circulation, and with this is carried through the arteries to all parts of the body, which opinion is indeed not very improbable. All the pulmonary pipes in the Worm are ftraight, and have on bladders, for only the perfect Beetle has them.

We fhall now leave the confiderations of thefe pipes, and explain more accurately the other parts. The firft of them that offers in our diffection is the ftomach; which is indeed feen moft diftinctly, when the Worm's skin is entirely opened, Tab. XXVII. fig. XI. and XII. *a a a a*. It then appears that almoft the whole body of the Worm is poffeffed by this part. It confifts of feveral coats, and has moving circular fibres, whereby its contents are agitated. It is always, except when it cafts its skin, found diftended and full of chewed wood, or the like fubftances, amongft which the creature lives; and this is the reafon that it appears bluifh, or fometimes reddifh, its contents being eafily feen through its coats. This ftomach is very narrow at its origin, at the mouth, whence it forms the gullet *b*; but it is a little after expanded until it makes its upper orifice called the œfophagus. In that part the ftomach *c* is on the infide in front armed with about feventy little tooth-like parts *d d*, whereof fome are longer than others. Thefe are divided into fix orders, whereof the two upper ones, 1, 2, look forward with their points, but the other four, 3, 4, 5, 6, which are confpicuous toward the lower parts of the ftomach, have their ends directed partly to the fore *e* and partly to the hinder *f* parts. All thefe open into the ftomach, in the fame manner as the appendages in fifhes open into the inteftine next to the ftomach. But I fhall not take upon me to affirm that one of thefe tubes is inferted into another; as is the cafe in the Whiting. I only would fay, that each tube feparately opens in the fame manner as may be feen in the Salmon, in which the pancreas opens into an ecphyfis with above fixty peculiar and diftinct tubes. A little lower the ftomach is rendered confpicuous by twenty-two whitifh glandular tubes, Tab. XXVII. fig. XI. XII. *g*, whofe ends are turned towards the hinder parts. Finally, about the lower part *h* of the ftomach, a little above the beginning of the pylorus, are likewife obferved thirty fuch tubes *i i*, which are alfo uneven, and fome fhorter than others; thefe are there fituated obliquely and run inward; thefe alfo open into the ftomach there, and their ends point forward. If the middle feries of the tubes before defcribed are broken off from, or taken out of, the ftomach, they refemble the crown of a trepan. On the other fide, where the ftomach lies in the belly of the Worm, and the tubes are directed towards the hinder parts, a future like the ridge of the peritonæum divides it *f*. There are infinite pulmonary fibres alfo inferted in the ftomach: on each fide of the ftomach are likewife placed fome fmall veffels *k k k k*, difpofed in a very regular and beautiful manner, which I call the vafcula varicofa & crocea, the fwollen and yellow veffels, after the example of the celebrated Malpighius, who in his excellent treatife on the Silkworms, has given that name to the like veffels in that infect. Where the ftomach terminates about the pylorus, is feen a narrow and fhort inteftine *l*, which is foon dilated *m* into a large, thick, and very capacious, though fhort, gut, and may be properly called the colon; for it is of the fame ftructure with the colon in the human fpecies. This inteftine

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is commonly found very full of excrements, which are like the dung of Dormice. It is by reafon of the thicknefs of this inteftine, which is naturally fo vaftly diftended, that the leaft or loweft annuli or rings are fmooth and tranfparent. Another reafon is, that, as the Worm has no fat about thefe parts, the filver-coloured pulmonary pipes, diftributed all over this inteftine, appear very beautifully through the tranfparent skin; and indeed the elegance of this fight is the more remarkable, becaufe the inteftine is of a purplifh or bluifh colour. The pulmonary pipes juft now mentioned reach on each fide *n n*, from the points of refpiration to this inteftine, and are diftributed thereon, as well as on the extremity of the ftomach and ftraight gut. I have omitted reprefenting here the other pulmonary pipes, that I might be able to exhibit the other eight orifices *o o o o* thereof in their natural fituation, and as they fhew themfelves when the fat and all other impediments are removed. This inteftine bends itfelf by degrees towards the ftomach, and there ends in a narrower canal, which is directly under it *p*, and which I call the ftraight gut; becaufe it agrees with that inteftine in figure, infertion and ufe.

I at firft fuppofed the fpinal marrow, Tab. XXVIII. fig. 1. to be in this, as it is in other infects. But afterwards, by opening two Worms which I had kept fince the laft year, I obferved that the marrow in this creature differed very much, not only from that of other infects, but alfo from that of the Silkworms, to which in many things elfe the Worm has great refemblance. As the marrow in the Silkworm confifts of many globules, which the celebrated Malpighius has been pleafed to call fo many brains, this, being formed in a quite different manner, fcarce extends to the third or fourth annular divifion of the body; but whatever part of it afterwards reaches to the other rings of the Worms, or whether what we fee there are no more than nerves fhooting from this principal body of the marrow; which, like fun-beams, beautifully and wonderfully diftribute themfelves through the body of the creature, and thus give fenfe and motion to the circumjacent mufcular parts, none yet can fay. Though there is a diftribution like this in the Silkworm, yet the fpinal marrow itfelf in that infect is extended through the whole body. Hence the marrow in the Coffus is very fhort, but the nerves are longer. I have again, fince the firft experiments, examined this marrow in a fmaller Worm, which I had raifed from the egg; but becaufe the body of the Worm is very fhort and compact, the marrow is therefore fituated fomewhat deeper, and thence appears very diftinct and beautiful. The *a* brain of the Coffus is placed in the head, and confifts of two hemifpheres, which together form one body. In the fore part are feen four little nerves iffuing out of the fubftance of the brain; alfo, out of each fide of the brain there iffue two remarkable nerves *b*, which firft leave a large opening between them, and afterwards again meet together a little lower, and there conftitute the body of the marrow *c*. This marrow, it appears, may be divided into fourteen globules, as it were diftinct, whereof the three laft together form one more globular divifion: moreover, the nerves very elegantly branch as they fpring out of this marrow.

We muft here obferve that the gullet paffes through the opening of the marrow which we have juft named, in its courfe towards the external mouth of the Worm. And indeed there was a neceffity for this ftructure, for as the ftomach and gullet are fituated in the neck and belly, and the brain lies above in the head, the marrow muft neceffarily have been fituated only on one fide, unlefs there had been a hole in it for the gullet to pafs through; hence it is contrived that the marrow poffeffes the middle of the body. The moft wife Architect of the univerfe has taken care, by means of this opening, that the marrow fhould not be forced to twift or turn itfelf round about the gullet, which could fcarce have been any other way avoided. In the fame manner the gullet paffes through an opening of the marrow in Silkworms: this the famous Malpighius has neither defcribed nor delineated. This author has likewife delineated fewer globules of marrow than are really in the Silkworm, and he has entirely omitted the brain. But it is eafy to add to what has been difcovered before. As this marrow is divided only once, and that at the beginning of its courfe in this Worm, it opens many times in the Silkworms, as Malpighius has very juft remarked. It is alfo further remarkable that two confiderable branches of the pulmonary tubes, which are filver coloured, and glitter like mother of pearl, are obferved to pafs over the marrow of the Coffus in many ferpentine windings. Thefe branches with their ramifications accompany the nerves iffuing out of the fpinal marrow, unto their fineft or moft delicate divifions, which is alfo the cafe in Silkworms. However great, therefore, the difference may be between the marrow of the Coffus and Silkworm, the brain and branching nerves meet again in both. The nervus recurrens, Tab. XXVIII. fig. 11, deferves moft confideration of any; becaufe, as in larger animals, and in man, this provides nerves for the beginning of the ftomach, and other parts adjacent: it performs the fame office equally in the Coffus and Silkworm. But in order to underftand how this is managed, I muft repeat what I have before obferved, that the gullet paffes from the external mouth of the creature, through the opening of the marrow towards the ftomach, and that therefore the marrow feems to be divided into two parts, purpofely that it might tranfmit the gullet. A further advantage that arifes from this is, that the brain is there lodged gently on the gullet, and is joined to it by means

means of the emitted nerves and connecting pulmonary pipes; so that the brain lies above on the gullet, and again the gullet and stomach are placed upon the spinal marrow; which part having no bone, is thus defended by them. The brain then being situated in the manner thus mentioned in the Coffus and in Silk-worms, emits underneath from its basis two tender little nerves, which I represent, fig. II. *aa*, as they appear when cut out of the Coffus. These nerves, called recurrentes, are directly from thence carried *b b* upwards towards the mouth, and being then very beautifully bent they run back *c c*, and uniting *d* a little above the brain, form a knot there. Out of this knot there springs another nerve *e*, which being conveyed under the brain, and descending along the gullet by degrees towards the lower parts, reaches to the beginning of the stomach, and there, before it inserts its branches in the stomach, making another knot less than the former, at last terminates in numerous very small nerves *g*: but these I could not trace further in the present experiments; though I am confident I could do a great many more things in these matters by the help of some peculiar methods of dissection, if I had not been then stinted in time.

As these nervi recurrentes are extremely remarkable and worthy of consideration, I have therefore represented them separately, and somewhat beyond their natural size. In the next place I have added a very exact figure, wherein the brain, fig. III. *a*, the spinal marrow *b b b*, &c. the nervus recurrens, and the rest of the branching nerves are shewn as they appear in Silk-worms. But there are two of these nerves very remarkable *p p*, which I would have the reader seriously and repeatedly consider: they are perforated *s s* in a wonderful manner by the vassa deferentia of the testicles in the Silk-worm Butterfly *r r*. But whether this conduces to pleasure in this species of insects, or to any other use, I leave others to determine. I have in the same manner delineated with the others the genitals of the Silk-worm Butterfly, and expressed them in the same figure with these nerves. A short explanation of this, as well as of all the other figures, will be found at the end of this work.

I have found out an excellent and uncommon method of preserving all these parts of the brain and marrow, by the help of which I can form them into a body, and keep them in their natural colour and size; whereas otherwise they are utterly destroyed by keeping. I shall communicate it when I publish my peculiar anatomical observations. I have, as a specimen of the use of this method, preserved in this manner a great many such minute parts, which though they cannot be investigated and examined without infinite industry and tedious labour, in the creatures themselves, yet when they are thus preserved, present themselves more familiarly to view than in their natural bodies.

I cannot in the course of this history avoid relating, how much the Peacocks and Peahens are delighted with eating these Worms; and hence I am inclined to believe what Mouffet alledges from Pliny and Hieronymus, that the ancients used to eat them as a very delicate kind of food in Pontus and Phrygia. But probably this was the species of Coffi, out of which the larger Beetles are produced. If any person would eat the Coffi of our country, they must be first kept fasting until all their excrements are consumed. When I have a mind to keep the Worm itself for future observations, I make a small incision in the hinder part of its body, and having afterwards pressed out the entrails through the wound, I fill the cavity with injected wax. Another method is this: all the fat of the Coffus must be first consumed with oil of turpentine, and then it may be preserved according to art. This different and much more uncommon method of preserving, I shall likewise explain in due time *.

C H A P. IV.

The manner wherein the Worm is changed: how its inward parts are transformed in their increase and growth, and the wonderful metamorphosis of the Worm into a Nymph. Also the method whereby the points of respiration, or breathing holes, are transposed: to which are added many uncommon observations.

WHEN the time of this Worm's change approaches, which in the year 1673 happened on the sixteenth of August, in those I observed the Coffi penetrate deeper into the ground, or into whatsoever substance they inhabit, and seek for places that are more firm or compact, wherein with the pressure of their hinder part, they form a very artificial oval cavity, Tab. XXVIII. fig. IV. every where smooth and polished. They lie a little while

* The Beetles are a genus of insects scarce less numerous than the Butterflies. We owe the first rational attempt towards arranging them, and disposing them in method, to our countryman Dr. Martin Lister: he divided them first into the land and water kinds: the first comprehend all those called by this author Scarabæi; the latter Hydrocanthari, or water Beetles. These last are of two kinds, according to their place of living, some delighting in fresh, others in salt waters. There are vast differences in their horns or antennæ, of which we shall speak presently; but these do not so happily distinguish them as the two great divisions of the Butterflies.

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immoveable in this cavity; and immediately after they become, by degrees, by voiding the excrements and by the evaporation of their humidity, more ſlender, ſhorter, and uneven in the body, with more furrows or wrinkles than before; theſe, however, are alſo diſpoſed on the ſkin in a very beautiful manner: and hence both the diſtention and clearneſs of the ſkin diſappears ſo perfectly, that one would think the creatures were ſtarved by degrees, and their ſubſtance conſumed with hunger. It is remarkable that at this time the internal parts of theſe Worms do not appear protuberant through the ſkin, as is the caſe in Silk-worms, and in the Worms of Bees and other inſects; though one may ſee even theſe already under the skin, and alſo diſtinguiſh by what degrees they increaſe.

Before I proſecute this matter further, it is neceſſary to know, that if the Coſſus be diſſected about this time, its diviſion into the head, thorax, and belly, may be diſtinguiſhed very clearly. The gullet, fig. v. *a*, keeps its original form: but the ſtomach *b b* is changed and greatly contracted: the ſame likewiſe happens about its appendages, *c c c*, for theſe almoſt totally vaniſh. The vaſa crocea or varicoſa *d d*, the yellow or knotted veſſels beforementioned become more looſe and free; though in the mean time they do not yet ſeparate from the ſtomach. On the hinder part of the ſtomach, about the pylorus *e*, is ſeen the inſertion of theſe veſſels; for they ariſe there in four diſtinct tubes, ſo that properly they ought to be called inteſtina caeca, cloſe or blind guts. The ſame may be likewiſe ſeen in diſſecting the Bee-worm, in the figures of which I have likewiſe delineated theſe veſſels. The inteſtine colon *f* to this time nearly keeps its bigneſs, nay, it now preſents *g* its little cells to view more diſtinctly than ever. Towards the hinder parts, under this, or towards the inteſtinum rectum *h*, are ſeen curious veſſels twiſted in a wonderful and very beautiful manner, on each ſide of that inteſtine *i i*. We may likewiſe at this time eaſily divide the ſubſtance of the ſtomach into its three coats, and diſtinguiſh its moving fibres.

It is admirable beyond all comprehenſion, how the Worm of the Hornet that is to put on the form of a Nymph, diſcharges at the ſame time all its excrements, together with the inward coat of the inteſtine, or rather of the ſtomach, which embraces or contains them; ſo that by this means this entire membrane and all the collected fœces are thrown out of the body together. The ſame thing happens in this caſe as does with reſpect to infants whilſt encloſed in the mother's womb: for they likewiſe retain together in their inteſtines until the time of birth all the excrements which are formed in the ſpace of nine months. I have alſo obſerved the ſame thing exactly in the Calves from the Cow's belly: nay, what is very ſingular is, I have found in theſe excrements hairs in every reſpect like thoſe that cover the ſurface of the body, and particularly thoſe about their mouth. From this obſervation I really think it is moſt clearly proved that animals often lick their body in the uterus with their tongue, and thus ſwallow their own hairs with their food; and that thoſe hairs are afterwards mixed with excrements as I have found them. Therefore it is moſt ſtrongly demonſtrated, that the humours wherein the animals ſwim in the uterus, and which are likewiſe found in their ſtomachs, ſerve them as food. Their excrements are whitiſh in the upper part of the inteſtines, and yellow a little lower; a little deeper they are of a yellow green and blue; and at length, in the end, they are of a brown and blackiſh colour. The excrements that are found in the Worms of Hornets are in all reſpects of the ſame form, figure, and ſubſtance: hence it is clearly evident, that all the Worms of Hornets feed upon one kind of food, and this is principally a ſmall ſpecies of Cantharides. In theſe Flies the little parts over the eyes, the legs, and the caſes which cover the wings, are obſerved to glitter like gold, and theſe are found in their fœces. The Hornets therefore bring up their young like birds of prey.

After we have obſerved the manner wherein the external and internal parts are changed by a ſlow accretion in the Coſſus, it gives us pleaſure to obſerve that ſuch of its parts as are not to be changed at all, and others which have lately increaſed by degrees under the ſkin, are gently diſtended by the force of the blood and impelled humours: hence it happens, that the body in general contracting itſelf more and more, and all the blood being propelled towards the fore parts, the ſkull at length opens very artificially into three parts; which likewiſe happens, as we have before obſerved, in the change of the skin, which the Worm undergoes. The skin then likewiſe opening in the middle of the back, is, by means of an undulating motion, which is obſerved along the annular inciſions of the back and the reſt of the body, carried down inſenſibly by degrees: and hence the eyes and horns, the lip, and the ſharp-pointed antennæ, caſt their exuviæ or skins at one and the ſame time, and are extended, and inflated with blood, humours, and air: they thus acquire by degrees the ſituation which they before had in the Coſſus. Whilſt all theſe things are doing, a watery and thin moiſture is diffuſed between the new and old ſeparating skin, which renders the parting of the two the eaſier.

The firſt part of the Nymph that appears after this change of the skin, is the horn on the noſe, fig. VI. VII. and VIII. *a*, which before lay under the skull in the Coſſus ſtate. Under this are afterwards ſeen ſome very low prominences on the baſis of the horn *b*. At each ſide of it alſo two ſpherical tubercles appear *cc*, iſſuing from the teeth of the Coſſus, which are much ſhorter here in the Nymph as as alſo in the future Beetle, than they were in the Coſſus or Worm. Near theſe tubercles on each ſide are likewiſe ſeen two other pair of ſphericle ſimilar tubercles *e e*, which ſprung from the horns *f f* of the Coſſus, and which are to be afterwards changed into the horns of the Beetle. Two ſuch little parts alſo, but more oval in their ſhape, are obſerved *g g* to be placed on each of the inward parts of the ſides of the former tubercles. Theſe little parts have their origin from the jointed *h h* briſtly hairs of the Coſſus; and are likewiſe, though in another form, found afterwards in the Beetle. Three beautiful ſhort tubercles preſent themſelves alſo in the middle *i*, which upon changing the ſkin have likewiſe ariſen from thoſe particles, which may be ſeen in the head of the Worm under the letter *k*. A little under theſe there appears alſo a larger ſphericle diviſion *l*, which is horny or bony in the future Beetle, and forms the neck which is beſet on each ſide with hairs. Above this, near the horn, is ſeen on each ſide the breaſt bone *m*. A little lower on the breaſt is ſeen the firſt pair of legs 1, 1, with their joints: and under theſe another pair 2, 2. Then follow the *n n* ſheaths or caſes of the wings on each ſide, under which a part of the covered wings *o o* is likewiſe prominent. Theſe wings appear at this time beautifully expanded by the force of the blood and air that are by degrees impelled inwardly, though they were before complicated, and appeared as if grown together under the ſkin of the Coſſus. Below theſe is placed the laſt pair of legs 3, 3, which are in ſome meaſure covered with the wings and their caſes. All theſe legs and their joints are ſtretched out ſtiff, and diſtended with the fluids of the body and air, and thus remain without any motion fixed in the ſame poſture, until the Nymph is changed into a Beetle. Finally, under the laſt pair of legs may be ſeen the rings of the abdomen *p p*, diveſted of their ſkin; and the extremity of the fundament *q*, out of which the inteſtinum rectum has caſt its exuvia or ſkin, as the gullet did with the upper parts. Theſe little parts are like two ſmall ſhields. As to the eyes they are very conſpicuous in the Nymph, but they cannot be repreſented by the ſame figure, becauſe they are ſituated a little deeper behind the horns. The whole motion of the external parts of the Worm is now totally loſt, in the ſame manner as it was before when the Worm was in its egg: hence the creature is twice as it were in a uterus, and twice in the ſtate of a fœtus. Some ſmall motion remains in the tail or fundament of the Nymph, becauſe the extremity of the abdomen undergoes the leaſt change of all. Thus the Nymph, by moving the hinder rings of its body or tail, can move itſelf and change its ſituation in its little cell: this is likewiſe performed by the Chryſalis of the Silk-worm when it lies in its web.

In this moſt wonderful change of the ſkin, and tranſpoſition of limbs and parts of this inſect, nothing demands greater attention, than what we may obſerve about the points of reſpiration: for though each of thoſe nine points which are ſituated on each ſide of the body caſts a ſkin, yet this can be diſtinctly affirmed only of the five foremoſt ones, for the four loweſt or laſt points on each ſide change their ſkin as the reſt, but they loſe all their priſtine form at the ſame time; three of them on each ſide become ſhorter, and the fourth is entirely cloſed up. At the very ſame time that the Worm, under this prodigious change of its ſkin, is transformed into a Nymph, a vaſt number of diſtinct tubules or pipes is likewiſe thrown out from all thoſe reſpiratory points, and theſe tubes, being each obliged to paſs through that narrow orifice, appear like ſo many ſmall and ſimple filaments, though, in reality, each of theſe eighteen little fibres, as they ſeem, is compoſed of many pulmonary pipes, that are laid cloſe together.

In order to underſtand theſe things the better, I ſhall add a figure to the deſcription of them, and in Tab. XXVIII. fig. IX. a Nymph of the Coſſus laid on its belly, and ſhall exhibit all the annular diviſions and points of reſpiration in its back. Theſe points ſhall be afterwards ſeverally repreſented in their ſituation, as they appear after the Nymph is changed into a Beetle. The firſt thing then ſeen here is the horn of the noſe 1, fixed on the head, which conſtitutes as it were the firſt ring of the creature: then follows the ſecond annular inciſion 2, wherein the firſt point of reſpiration is placed, ſo ſituated laterally under the firſt pair of legs in the breaſt, that it does not appear but when the Nymph is killed. The third and fourth rings, 3, 4, are ſeen both without points of reſpiration, becauſe the wings and caſes thereof are placed there *. Beſides theſe, two annular inciſions in the Nymph are concreted into one ring, and then form the lower part of the thorax or back. In the mean time, when theſe parts are caſting their ſkin, on each ſide between the rings of the thorax, two little ropes as it were of pulmonary tubes are caſt out of the body, as has been before repreſented in the figure, where we have deſcribed the change of the ſkin which the Worm itſelf undergoes. But theſe apertures are afterwards cloſed up in the Nymph, until having caſt its ſkin, it at length becomes a perfect Beetle, wherein theſe orifices are at length totally aboliſhed. The fifth ring 5, contains the ſecond point of reſpiration, which

* In the outer caſes of the wings in Beetles there is a vaſt diſtinction, not only in colouring and ornament, but in ſhape; ſome cover the whole body, and are a defence to the inner wings, with little foldings of thoſe more delicate parts: but in others theſe outer wings or caſes of wings are ſhort, and only fall over the ſhoulders. This is the caſe in that common and diſtaſteful black Beetle which crawls about damp hedges, with its body naked and annular; the under wings are beautifully folded up under their ſmall caſes.

cannot be ſeen diſtinctly, being ſituated partly under the wings of the Nymph. But a particular, very worthy of notice here, is, that this other point of reſpiration is in the Nymph removed to a greater diſtance from the firſt, than it had been at firſt in the Coſſus itſelf, and as I have figured it in that ſtate; ſo that by this means it is conſiderably drawn back towards the hinder parts. The ſixth ring 6, next to the former, contains the third point of reſpiration, which is very diſtinctly ſeen externally in the Nymph, at the extremity of the abdomen. In like manner the ſeventh ring 7, ſhews the fourth point of reſpiration, and the eighth 8, ſhews the fifth. But the ſixth and ſeventh points of reſpiration, conſpicuous in the ninth and tenth 9, 10, rings are again cloſer. The eleventh, twelfth and thirteenth rings 11, 12, 13, conſtitute as it were one connected joint together; and the eighth and ninth points of reſpiration, which are ſituated at or near theſe rings in the Worm, likewiſe become not only cloſer and more compact, but the laſt of them is in this ſtate almoſt inviſible. As to the fourteenth ring 14, it is not viſible when the Nymph is in this manner placed on its belly, but on the other ſide it is ſeen beautifully, reſembling two oblong oval little ſhields. O wonderful changes! whereby the creature comes into the world as it were new formed, and yet is moſt certainly the ſame that it was in the Worm.

The Worm being in this manner diſengaged from its ſkin, transformed by accretion, and having its limbs and parts changed into the ſtate of a Nymph, cloſely twiſts and compreſſes the caſt ſkin by the motion of its fundament, and the ſkin is afterwards thrown towards the hinder parts under the belly. The Nymph is at that time very white, only that on the fifth, ſixth, eighth, ninth and tenth rings of the back, there appear ſome delicate or horny hardiſh corpuſcles, which approach to a bright red colour; in the little ſhields alſo of the laſt ring, and here and there in its body and legs the like ſubſtances are at this time alſo ſeen. The Worm or rather the Nymph is at this time very delicate, tender and flexible, and as it becomes remarkably ſhorter, on the other hand it is expanded conſiderably in breadth and thickneſs; for the blood and air have very conſpicuouſly inflated the wings and the reſt of the parts, in the part towards the head, and diſtended them ſo that they are become rigid. If we view this Nymph nearer, we obſerve that the tranſparent productions of the windpipe appear not only in the legs, but in the wings themſelves, and in their ſheaths and caſes; nay, they are ſeen alſo in the ſubſtance of the horny or bony part that ſtrengthens the thorax.

About this time the Worm or Nymph reſembles a tender young infant very lately brought into the world, and which is rolled up in its firſt ſwaddling cloaths, and cannot yet bear much handling. We may more properly indeed compare this Nymph to an Embryo, which, being lately conceived in the uterus, may, by force of the injuries offered it by the mother's imagination, be injured in various manners: for the impreſſions which the Nymph receives at this tender age, are not aboliſhed even when it is grown up or is become a Beetle. Hence, if the horn, legs, or other parts are bent in the Nymph, or diſturbed in any manner, they always afterwards remain thus deformed in the Beetle; and the Beetle carries with it through life the veſtiges or remains of all the injuries inflicted on this feeble and tender little creature; this is agreeable to the ſentiment of the poet:

Quo ſemel eſt imbuta recens, ſervabit odorem
teſta diu. ——

That is,
" A new veſſel will long preſerve the ſcent of the firſt liquor poured into it."

This change therefore merits the greateſt admiration and the moſt attentive regard, by means of which the creature for ſome days exhibits the future parts of the Beetle ſo finely and beautifully diſpoſed, and formed in ſuch a manner, as that they will one day ſerve the creature in a more perfect ſtate of life, to walk, fly, and take its nouriſhment. I therefore really think, that the Coſſus of this ſpecies comſtituted in the form of a Nymph, affords an appearance ſo ſingular, that among all the ſtrange and aſtoniſhing appearances of inſects, it cannot be equalled. I ſhould be very glad to ſee hereafter the Nymph of the ſtag-horned Beetle, for I ſhould think it would make a much more ſplendid figure when it prepares itſelf like a bride, in all its decorations, for a new and more noble ſtate of life.

The Chryſalis of the ſwift Butterfly deſcribed by J. Banhinus in the year 1590, among the Mouches ou Papillons non vulgaires, or the uncommon Flies or Butterflies, is very rare and admirable. Aldrovandus, Lib. II. Cap. de Chryſ. Tab. VII. fig. 1. exhibits a kind of figure thereof. Mouffet alſo, pag. 105, deſcribes the leaſt ſpecies of the ſaid Butterflies, and properly calls it the ſwifteſt of all, for indeed the ſwallows do not fly with greater velocity than theſe little creatures.

One thing very ſingular in theſe Butterflies is, that they fly and eat at the ſame time, though this alſo is the caſe with ſwallows, and among inſects with the Libella or Dragon-Fly. On the other hand ſome Flies, after they have ſeized on their prey, reſt in ſome convenient place to devour it, as in particular the Wolf-Fly. But as Swallows eat and fly at the ſame time, ſo theſe, at other times nimble Butterflies, flutter when they feed in ſo ſlow, regular, and orderly a manner about the flowers where the food proper for them is depoſited, that you would imagine they had loſt all motion, and hung ſuſpended in the air; but they are hard at work all the time, for they then thruſt out a very ſlender proboſcis or trunk about two inches long, with two perforations in it, through which

which they ſuck the honey of the flower; and this being exhauſted, they ſo quickly draw back this ſurpriſing organ, and ſo artfully coil it up between the little forked parts which are placed under their eyes, that it entirely diſappears, ſo that to find it out, one muſt be well accuſtomed to the ſtudy of theſe creatures. This inſect being ſcarce, I have given the figures of it, as it appears in the reſpective ſtages of its exiſtence as Worm, Tab. XXIX. fig. I. Chryſalis, fig. II. and Butterfly, fig. III.

As the manner of feeding of this Butterfly is very ſingular, I ſhall add another obſervation of the ſame kind, in regard to the manner of feeding of a certain aquatic inſect that always lives under water. This inſect is, properly ſpeaking, no other than a peculiar kind of water Worm, conſiſting of thirteen rings, the head and tail included. The head is very large in proportion to the creature's ſize. It has ſix hairy legs, fig. IV. *a a*, beſides two ſpots or ſmall parts covered with hair likewiſe *b*, which terminate the tail, and are uſed by the creature when it ſwims as a rudder to govern its motions. The inſect by means of this tail, can alſo at pleaſure ſuſpend itſelf on or near the ſurface of the water; when it erects its tail above the ſurface, the water flows from it on every ſide, and thus is this ſuſpenſion formed. This inſect has beſides in its head two very remarkable teeth, or more properly jaws *c c*, which are large, ſharp, crooked, and very ſtrong, and it is perhaps able to contain the muſcles ſuch teeth or jaws require, that nature has made the head ſo large. This Worm has ſix eyes *d d* on each ſide of the head. I have here repreſented eight of them. There are beſides ſix articulated briſtles belonging to it, of which four *ee ee* lie underneath and between the teeth, and the two others under the head *f f*; but ſome may imagine that theſe laſt ſhould be called horns.

This is a cruſtaceous creature like a Shrimp. On each ſide of the body are ſix holes for reſpiration *g* in the rings of the abdomen, with two more for the ſame purpoſe under the body near the fore legs. This Worm is repreſented in the moſt curious figures of Hoefnagel, that were engraved after his minute and moſt accurate deſigns, part firſt, page I. Mouffet alſo deſcribes it in the 37th chapter of his theatre of inſects, and gives in ſome ſort a drawing of it. This inſect lives entirely on other little creatures that inhabit the ſame element, in particular on the Scrophula and ſmall freſh water ſhell fiſh. When about to eat, he ſeizes with the two teeth we have mentioned the little creatures that come in his way, and pierces their body with its ſharp and crooked points, which being perforated from the point to the root, he in a ſurpriſing manner ſucks through them into his mouth the blood of the unfortunate captive. This may be eaſily ſeen, eſpecially when the blood of his prey is of a red colour, as the teeth are tranſparent. I threw to this Worm a bit of a Coſſus, at the ſame time carefully obſerving with a microſcope how he devoured it: together with the blood, there aſcended ſome air in ſmall bubbles through the cavities in his teeth. The ſight of this creature in the water is very acute, for which purpoſe nature has ſupplied it, as I already mentioned, with twelve black eyes, which are placed at ſome diſtance from one another, but theſe eyes, like the eyes of other inſects, have no motion, and therefore are placed in a different manner from thoſe of Crabs, Crawfiſh and Shrimps, which are moveable. When therefore this Worm perceives any thing that it likes, it immediately darts at the object through the water, ſeizes it, and pierces it with its ſharp pointed teeth. In this manner we may procure ourſelves a very entertaining and ſurpriſing ſight, by throwing to it a ſmall Earthworm; for let this laſt move, twine, and otherwiſe beſtir itſelf ever ſo much, the other keeps his hold, and very calmly ſucks the blood of his priſoner. The inteſtines of this Worm differ extremely from thoſe of land inſects; its windpipe has fewer ramifications, though theſe at the ſame are more large and ſpacious. They are likewiſe more membranaceous, of a leſs firm texture, and not of quite ſo deep a colour. The heart is ſituated near the back, and the ſpinal marrow in the lower part of the body. This laſt conſiſts of globules as in the Silkworm, but theſe lie ſo cloſe to each other that they form a connected body of marrow, more like that of the Coſſus than a Silkworm. In the part where the nerves unite with theſe globules, the ſpinal marrow itſelf looks like a bracelet compoſed of coral beads ſtrung upon two threads. The remaining parts are the ſtomach and the inteſtines, which are partly of a white and partly of a bluiſh gray colour, the ſame with their contents, from which indeed they receive it. The Vaſa Crocea, or yellow veſſels, as they are uſually called from their colour, are in this inſect purple, or otherwiſe, they are thick ſet with purple ſpots, but they look whitiſh at bottom, which affords a very agreeable ſight.

On examining with a microſcope the teeth of this Worm, they appear very ſharp pointed, Tab. XXIX. fig. V. *a*, and a little bent towards the point. There was likewiſe a kind of ſuture *b* in that part where I cut out one of them, formed by a ſharp protuberance in the middle of the upper ſegment, with a ſuitable cavity in the middle of the lower to receive it, the edges about both being ſmooth and even *c*. The aperture by which this inſect ſucks the blood of its prey, lies on the ſurface of the tooth near the point *d*, and reſembles an oblong ſlit, with black edges covered with very fine hairs. It is extremely probable that ſome peculiar ſpecies of the Water Beetle proceeds from this Worm, when having remained in the water a ſufficient time, it betakes itſelf to the land to undergo its mutation; but this is mere conjecture. The horſe Fly has another method of feeding itſelf, being furniſhed, as I have elſewhere remarked, with a ſting as well as a trunk or proboſcis. As to the

the Gad Fly and its Worm, I ſhall hereafter treat of it by itſelf, under the fourth order or claſs to which it belongs; but I cannot help remarking in this place, that the Worm from which it comes breathes by its anus, and carries its legs in its mouth near the jaws; thus ſerving to prove that the Almighty can form veſſels of every kind like the potter, ſome for more, and others for leſs honourable purpoſes, but all to his own glory; ſo that there is not a creature, however contemptible in appearance, which does not clearly point out the exiſtence, and loudly ſing forth and extol the adorable perfections of a ſupreme Being.

CHAP. V.

In what manner the Nymph is filled with a ſuperfluous moiſture, which afterwards evaporates. The anatomy of the Nymph. How, on caſting off its ſkin, it becomes a Beetle, with ſome wonderful diſcoveries in natural hiſtory.

HAVING ſhewn in the foregoing chapter what the Nymph is, and by what means the Worm puts on this elegant form, to prepare itſelf as a bride for its enſuing nuptials, and for the act of generation; I ſhall now treat of thoſe changes, by means of which the Nymph attains this preſent ſtate, and at the ſame time give a diſſection of ſome of its internal parts; for thus the reader will more eaſily underſtand how this Nymph grows at laſt to a Beetle, and being arrived, as ſuch, to a ſtate of maturity and perfection, propagates its ſpecies.

The firſt thing to be conſidered on this occaſion, is that peculiar motion of the blood and humours, which expand the parts of the Nymph, and make it weigh at firſt, a little after its change, a great deal more than it does even afterwards in the Beetle ſtate. This ſingularity is likewiſe remarkable in the Nymphs of Bees and Hornets. The Nymph of the Hornet in particular weighs ten times as much as the Hornet itſelf. This makes me conſider the Nymph under theſe circumſtances as a dropſical perſon, who, by having his limbs ſwelled with ſuperabundant humours, loſes the power of thoſe muſcles by which they were to be put in motion, and thus remains inactive till the ſuperfluous moiſture is ſome way or another diſſipated. Nor is it the limbs alone that are thus ſwelled in the Nymph; all the muſcles themſelves partake of the change, and even the very bone into which they are inſerted. This, which was before of a horny ſubſtance, loſes its ſolidity, and by becoming membranaceous and ſoft, and in a manner fluid like water, is no longer capable of being acted upon by them, and continues in this condition, till the ſuperfluous humours are evaporated in a certain ſpace of time, which is abſolutely neceſſary for that purpoſe. We may perceive by a continued obſervation, that the external skin of the Nymph is at firſt extremely delicate, that it hardens, as it dries, by degrees, and that its colour grows more and more yellow, till it changes at length to a deep red, after that to a deep brown, and at laſt to a light red. But all theſe appearances are owing to the growth of the internal parts, in order to form the future Beetles, as they ſhew themſelves through a tranſparent skin that covers them.

When this Nymph has paſſed ſome days in ſweating off the ſuperfluous moiſture, with which it is loaded, a little articulated whitiſh line appears like a ſlender thread through the tranſparent skin, with which the legs are covered, which is no other than the firſt rudiment of that horny or bony ſubſtance, which begins to harden, and is in time to conſtitute the legs of the creature. On ſtripping off this skin, and attentively examining the ſolid or horny part it contains, the latter appears to float in a limpid fluid, which ſurrounds it on every ſide, and is at this time ſo very tender that it is eaſily injured, and will fall off on the ſlighteſt motion. But what ſeems chiefly to claim our wonder is, that the Worm which grows from the noſe of the male Beetle of this ſpecies, ſhould be ſo very hard at its perfect growth, as, according to Mouffet, page 153, to bear being ſharpened on a grinding-ſtone; whereas the ſame organ, while the inſect is in a Nymph ſtate, is altogether ſoft, and more like a fluid than a ſolid ſubſtance.

On diſſecting ſome of theſe Nymphs after they had been in that ſtate a little time, I found the horn of the noſe filled with a kind of jelly, and this matter broke out at the wound made to examine it, every time the creature breathed, in the ſame manner as the blood of a man's body does when the ſide of the thorax is wounded. The eyes were now ſomewhat firmer, but nevertheleſs they were ſtill loaded with ſuperfluous humours. I found between the folds of the wings and the caſes that covered them, ſome inſects of the Louſe kind, which I have likewiſe often obſerved ſticking to the body of the Coſſus and to the Beetle itſelf; for there is perhaps no ſpecies of animals which is not troubled with this kind of vermin, though thoſe of one animal differ in ſhape from thoſe of another. Such part of the wings as had no caſe to cover them, had, to make up for that deficiency, a much thicker skin to defend them, than the parts which were thus ſheathed. On pulling the legs from the

the thorax, the skin came off from thofe of the future Beetle in the form of a ftiff fheath, juft as a boot comes off a man's leg. It is alfo very remarkable, that the extremities of the pulmonary tubes were inferted into this external skin of the infect. But I fhall hereafter fpeak of this matter more at large. The inteftines which lay in the abdomen were formed in quite a different manner from thofe of the Worm, of which I have before given a figure, and in particular they had more finus's. The ftomach itfelf ended in a kind of very fmall gut, and indeed all thefe alterations feemed requifite to prepare the parts to the great change in the body itfelf, which was grown at this time confiderably fhorter than before. But as the ftomach was greatly abridged, and therefore its mufcular parts had without doubt fuffered confiderable changes, both that and the inteftines were now foftened into a kind of flimy humour to facilitate fo furprifing a change. The pulmonary veffels retained their former fituation and figure. The whole abdomen was filled with a kind of calcarious fubftance refembling ftarch, and of fo bright a white as to dazzle the eyes of all who faw it. On a nearer examination of this fubftance, I found it to be nothing more than a collection of thofe little bags in which the fat is depofited, and which little by little lofe their form and office, and are at laft fo entirely wafted away, together with their contents, that not the leaft veftige of either is to be found in the fucceeding Beetle. About this time fome fpots are obfervable in this moft extraordinary fubftance, of a brighter white than the reft of it, and many of the pulmonary tubes feem to take their direction towards thefe particular parts. This induces me to think they may be the rudiments of the pneumatic bladders with which the Beetle is furnifhed in a vaft abundance, unlefs we are rather to confider fuch pneumatic bladders as confifting of the pulmonary tubes dilated occafionally to anfwer that purpofe. For my own part I cannot take upon me to decide this point. I obferved the fame things in the Nymphs of Bees, after I had finifhed the hiftory of thofe infects: but be this as it will, thefe fpots are fo brittle and tender in the Nymph that they are deftroyed by the flighteft touch: by their dazzling whitenefs alfo they hinder us from diftinguifhing properly the adjacent parts: for this reafon, to proceed well in our examination, we muft be conftantly wafhing with fair water the inteftines of the infect. Were it not for this obftacle, we might doubtlefs here diftinguifh many more things worth of notice. In the thorax, fome parts were a little more folid. The mufcular fibres of the legs and wings were fomewhat more firm or tough than the white of an egg juft beginning to harden. All the other parts were as foft and tender as poffible. On feparating the external skin of the body from the internal, the fpace between them was found to contain a great quantity of moifture, but in many places this feparation was abfolutely impoffible.

As the feveral parts in the Nymph grow by degrees ftronger and ftronger, the infect may be feen to make a proportionable ufe of them. We fee the legs move within the skin that covers them, and even the claws that terminate the legs begin to brandifh themfelves up and down. The fame is vifible, and in the fame manner, in the Aureliæ of Silkworms during the laft days before their tranfmutation: if during this period you ftrip the legs of their external skin, you will find very little moifture under it. Even the horny or bony fubftance which conftitutes the joints of the legs appears hard, perfectly formed, and covered with hair.

I cannot fay how long the fcene of this infect's mutation continues, having forgot to take notice of it, though at the fame time I was witnefs to the change of above fifty of thefe Nymphs into Beetles. Sometimes thefe infects remain in a Nymph ftate during the whole winter, efpecially when the Worms throw off their skins towards autumn, and a fudden cold fucceeding checks their further operations. Hence it happens that they remain without food for fome months, nor could they take it to any purpofe, their parts being too foft and tender to allow them to make ufe of it.

When the proper feafon of the Nymph's final change approaches, all its mufcular parts are obferved to grow ftronger and ftronger, to be the better able to fhake off their laft integuments, and this is performed in the fame manner exactly as in the already defcribed change of the Worm to a Nymph; fo that in this laft fkin, which is very delicate, the traces of the pulmonary tubes that have been pulled off and turned out become again vifible; nor is their number limited to eighteen, there appear abfolutely twenty of them, as has been already fufficiently obferved.

It is now proper to fee how all the parts of the infect, but efpecially the wings and their cafes, are at this time fwelled and extended by a flow of air, blood and humours, driven into them through the arteries and pulmonary tubes. About this time the wings are as foft and flexible as a piece of wet paper, fo that blood iffues from them at the leaft wound. But when they have acquired their due hardnefs, which in the fheath or cafes is very confiderable, the veffels that before yielded blood fo freely, are fo firmly clofed, that neither they nor the wings can by any cutting or tearing be brought to yield the leaft fluid. This induces me to advance as a thing not to be doubted, that whereas thefe wings and their cafes are fo full of veffels and pulmonary tubes, they ought to be confidered as confifting entirely of fuch veffels and tubes. It is alfo probable, for the fame reafon, that the membranes and skin of the other creatures are no more than a complication of veffels, as nerves, arteries, veins, lymphatic ducts and the like, for fo long as the embryo's of the human fpecies and of quadrupedes remain in the womb, their skin appears compofed of nothing elfe. The fame may be faid even of the bones themfelves;

 and

and this obſervation alone would be ſufficient to recommend to our attention the hiſtory of the inſect now under conſideration. It would take too much compaſs in this place to deſcribe the ſurpriſing alterations which happen in the membranaceous wings of butterflies, and how evidently nature manifeſts herſelf, and exhibits her wonderful powers in theſe minute creatures: certainly the great and wiſe ſovereign of the univerſe made every thing for our uſe, and to his own glory. All his creatures, the leaſt as well as the greateſt, furniſh us with proofs of his gracious intentions, his ſtupendous majeſty, and the immenſity of his power.

We therefore, on obſerving the mutations and tranſpoſitions of the growing parts of man and other animals, may well cry out with the royal prophet: "My ſubſtance was not "hid from thee, when I was made in ſecret "and curiouſly wrought in the loweſt parts "of the earth. Thine eyes did ſee my ſub-"ſtance, yet being unperfect; and in thy "book all my members were written, which "in continuance were faſhioned, when as yet "there was none of them. How precious "alſo are thy thoughts unto me, O God! "how great is the ſum of them!"

Hence we may juſtly declare, that inſects, even under this miſerable ſtate of mortal life, acquire as it were a heavenly exiſtence; for thoſe which in the former part of their life inhabited the earth, lived in mud, and under thorns and briers, and fed on coarſe proviſions, in their more perfect ſtate, raiſe themſelves into the purer air, and flying towards the skies, maintain themſelves with honey and oozing liquors of flowers: ſome of them can even abſtain from food during many months. Are not all theſe conditions much better than thoſe to which they were ſubject under the troubles and anxieties of a former more vile earthly life? but I ſhall illuſtrate theſe ſubjects more fully,when I have leiſure, in order thence to demonſtrate the glorious reſurrection of the dead, by the moſt evident and palpable proofs drawn from nature; for I can produce ſuch manifeſt examples and ſuch powerful arguments for the purification and ſucceeding glorification of bodies, from the hiſtory of inſects, that I do not doubt but ſuch unheard-of miracles will ſtrike all mankind with the higheſt amazement. Natural truths are perfectly convincing and wholly divine; ſince what is true proceeds from God, who is truth itſelf. And what is more true, than that the books of nature are thoſe viſible things, by the aſſiſtance of which, as by ſacred ſteps, we aſcend by various advances, to divine and eternal truths? for it is God himſelf who is the author of Nature.

C H A P. VI.

The difference between the male and female Rhinoceros Beetle, after the Nymph caſts its ſkin, and is changed into either of them. Of the points of reſpiration, the eyes, the brain, the optic nerves, the pulmonary tubes and pneumatick bladders. Of the heart, and of the genital organs of the male and female, with a moral concluſion.

THE Nymph of this curious Beetle being diſengaged from its skin, in the manner explained in the preceeding chapter, aſſumes a quite different form, in which it is dignified with the name of the Beetle, whoſe internal parts, with the difference between the male and female, I am now about to deſcribe. Before I begin this explanation, I muſt obſerve that the Nymphs, which have their horn prominent in the fore part, always become male Beetles in this ſpecies; but ſuch as have no horn always females: and there are very certain external ſigns for diſtinguiſhing the ſex of theſe inſects. Beſides, the males, which have ſmaller bodies than the females, have alſo two larger and more beautiful horns *, whoſe tops have knobs thereon made like combs; and, when the creature is flying, they are expanded in the manner of the leaves of an open book: this is a very wonderful ſight in ſome of the Beetle kind. But as ſome remarkable things occur, which are common to both male and female, I ſhall firſt deſcribe them, and afterwards proceed to the peculiar points which mark the difference of ſex.

The parts common to both are, firſt, the points of reſpiration ſituated outwardly; ſecondly, the eyes and the brain; thirdly, the pulmonary tubes and pneumatic bladders; and laſtly, the heart. The things peculiar to each are the horn and genital parts in the male, and the ovary in the female. I ſhall proceed to deſcribe theſe in order and with brevity: as to the particular deſcription of the other

* The antennæ of Beetles are of two kinds; thoſe which are pointed at the end, and thoſe which have that part ſhaped in the manner of a comb.

There is alſo a difference of a very particular kind in their inſertion, the greater part have them fixed upon the ſubſtance of the head; but in ſome they are carried upon a kind of trunk: the Beetles which have them in this ſtrange ſituation, are thoſe the antients called Gurguliones.

Upon theſe forms and inſertions of the antennæ may be eſtabliſhed an exact claſſical diſtribution of them, a thing yet wanted in natural hiſtory.

external

external and internal parts, the difpofition and manners, the ufe they make of their wings, and their food, and the length and fhortnefs of their lives, as alfo how far they are hurtful, and how far innocent, with other like refearches; thefe I fhall at prefent pafs untouched, partly becaufe I have not yet fufficiently fearched into them, and partly that I am fatigued beyond my ftrength, with inveftigating, delineating, and defcribing thofe amazing things. I muft have a long fpace of time to perfect all thefe inquiries; nor can any perfon execute fuch things perfectly, but he who can fpend his whole life upon them.

Of thofe things, which are outwardly confpicuous in this Beetle, the points of refpiration deferve our greateft attention; thefe I fhall now defcribe and reprefent by a figure, as they are naturally difpofed on one fide of the perfect infect; for they have the fame fituation and ftructure alfo as the other. They vary confiderably from thofe which are feen in the Worm, for here they are difpofed in a different order near each other, and are placed in a fomewhat oblique and declining fituation; by this means one of them occupies an higher place in the body than another; they are likewife more oval, not round, and are much deeper, or more hollow than before, and appear as it were like little trenches and furrows in the Beetle much more than in the Coffus: the cavities alfo of the canals which they diftribute internally in the body, are much wider and more open than they are obferved in the Worm; for as the Worms live in duft and under the earth, and creep up and down there, it was neceffary that their pulmonary tubes fhould have orifices more clofe and even, left the duft fhould flip into them.

The firft of thefe points is placed inwardly, Tab. XXIX. fig. VI. *a*, in the cavity of the fecond ring of the body, or in the os pectoris, or breaft bone; nor is it vifible there till after that bony fubftance has been feparated from the body. The fecond *b* is fomewhat further diftant from the firft, and being turned more toward the lower parts, is directed thence obliquely towards the other. This point, which is confpicuous immediately under the wings, is placed on the fide of the fifth ring of the body. The third *c* again is fituated fomewhat higher, along the courfe of the curvature of the abdomen, and this lying upon the fixth ring of the body, is not far diftant from the fecond. The fourth *d* again is placed fomewhat lower and nearer the former, and is fituated upon the feventh ring of the body. The fifth *e* ftands fomewhat lower and is placed on the eighth ring. Thefe five points of refpiration, whereof the Beetle has as many on the other fide, and which makes ten in all, are indeed the principal places through which it draws its breath; for the other eight, which were vifible in the Coffus, are in this perfect ftate of the creature partly preffed together, and fome totally clofed up; becaufe the body is become fo much fhorter than it was in the Worm. All thefe five points are covered in each fide of the body with the cafes or fheaths of the wings, except when the creature is flying; for at that time the fheaths of the wings are lifted up, and remain elevated without motion; hence thefe points are likewife at that time difcovered: and this feems continued that the Beetle might the more freely draw its breath on this occafion, fill its pneumatic bladders with air, and thus make itfelf lighter for flying.

Moreover on the ninth ring of the body there is obferved a fixth point *f*, on the tenth, a feventh *g*; and on the eleventh, an eighth *h*; all which are very confiderably contracted and depreffed, and run along each fide of the body. But as the abdomen terminates by converging into a fort of a point, and the twelfth, thirteenth, and fourteenth rings are wonderfully contracted and diminifhed in their diameter, hence the ninth point *i* of refpiration is totally obliterated in each fide of the body, as I have before with fufficient clearnefs defcribed and figured in the Nymph. But I now only reprefent the natural fituation of thefe points.

The eyes are alfo extremely remarkable in the perfect Beetle, and they differ very much from thofe in the Worm, as well in bignefs and number as in figure. Each fide of the head has one, which confifts of a congeries of many fmaller globules or little eyes, forming by their union as it were one common net or reticulated body. This is properly made of the tunica cornea, for the eyes of all the infects that I know, have the exterior tunica or coat conftructed or formed of a horny or bony matter, and divided like a honey comb into hexagonal parts, all which are on the upper part fpherical or projected like little globes. But thefe globular divifions are not in this Beetle fo remarkably protuberant as in Flies and Bees; they are much fmoother, more depreffed, and fmaller, and they have no hairs. Thefe horny divifions penetrate from the outmoft furface to the inmoft, and feem to be formed within by a kind of net of hexagonal pulmonary tubes running through each other. Within this net the uvea tunica, or a part analagous to it, is feen on the infide under the cornea. This is of a blackifh colour, and is regularly received into the inward cavity or hollows we have named in the cornea, fo that by this means it is to be found only in the uppermoft furface, and not in the bottom of the eye. In the eyes of men and quadrupedes the uvea finks to the bottom, and is alfo perforated in the anterior part; but neither of thefe is the cafe in the eye of the Beetle, and for this reafon no rays of light can be collected in this cafe inwardly in the eye; but they only pafs through the fpherical divifions of the cornea, and are then immediately ftopped upon the uvea. I would not prefume to affirm that the rays are by any means collected

lected, when they pass through the cornea, though this is not improbable. If one removes the uvea, by means of water and a fine pencil, from out of the inward cavity of the cornea; this latter becomes then all bright and clearly transparent.

After the uvea follows a matter or substance like glue; it is somewhat viscid, but thin, and divides itself into very fine filaments, Tab. XXIX. fig. VII. *a*: these may be taken for inverted pyramidal fibres. When the cornea tunica is removed from these filaments, blackish spots are seen on the eye, which are the remains of the uvea still sticking there; for the pyramidal fibres are by means of the uvea connected with or joined to the spherical apertures of the cornea. All these fibres terminate in a thick, fibrous, and inexpressibly white tunic or coat, Tab. XXIX. fig. VII. *b*; the substance of this, however, is of a darker colour *d*, where it is united to the optic nerve which is here separated *c*. Many pulmonary tubes likewise run up and down here, which strongly connect that coat with the optic nerve, which it receives: these air-pipes pass also through that white fibrous coat we have described, and are conveyed *e* along the inverted pyramidal fibres, reaching to the cornea itself in form of very delicate ramifications; and in my opinion form the hexagonal divisions of the eye. Here at length may be conceived, in what manner the eye, whilst the exuvia or skin is casting, acquires its extension, form, and roundness by the help of the internally impelled air and blood. The roots of these pulmonary tubes are found to be situated under the optic nerve, where they first provide for the coat, wherewith that delicate nerve is invested; and thus, with a considerable ramification adhering underneath, is also surrounded with or accompanied by such air-tubes.

But we must here take particular notice that these eyes are, in each side of the head, divided as it were into two parts, fig. VIII. *ff*, as I have represented in a particular figure, wherein is likewise exhibited *g* the horn of the head. This division is produced by means of two horny or bony prominences of the skull, which extend themselves from each side of the eye unto the outmost surface thereof; hence it happens that the eye is in the same manner divided in its internal part, fig. VII. *h*; since the inward structure is analagous to the outward. The optic nerve has no incision or division, but the pyramidal fibres are wanting where this incision is, because they evidently could be of no use there.

In order to discover these things accurately it is first necessary to lay the brain bare; for this purpose nothing more is requisite than to cut off the horn, if it be a male, with a sharp knife, and then to raise and separate the cranium or skull from the brain. After this, the brain *i* comes in view. This, as I have before observed, when I treated of the spinal marrow, consists of two globes united, and is by this means divided into a right and left part, as is likewise the case in men and in quadrupedes. It is indeed very remarkable that the brain is in this Beetle furnished with many pulmonary tubes, Tab. XXIX. fig. VII. *k*, which make a very beautiful appearance in the living animal. Optic nerves are observed to issue out of it on each side, which are much larger in the Beetle than they were before in the Worm. Moreover, a common kind of membrane is observed there, which invests both these nerves and the brain itself, and is sufficiently thick and strong: this may be properly called the dura mater. Numerous air-pipes run through this membrane, and interweave it as it were with one another, so that you would say this dura matter, when separated from the brain, is like an admirably beautiful net. The optic nerves are very slender where they issue from the brain *ll*; but they are considerably dilated *mm* a little after, and then again they grow small *nn*, until at length they are swollen again where they approach to the inward compages or reticulations of the eye *o*. In that part these nerves are enclosed and surrounded by the interior parts of the eye, and when greatly magnified resemble the head of a Dutch sailor covered with a shaggy cap, such as sea-faring persons use to wear: I compare to these shaggy hairs, those pyramidal fibres which terminate in the convexity of the white fibrous coat.

It may not be improper to observe here that this Beetle is very short sighted, or pore-blind. I therefore would have the reader consider the construction and difference of the Bee's eye, which sees more acutely in the day time; for he will find that the optic nerve in the Bee does not come so very near to the eye, nor is in itself so remarkable and conspicuous as in this Beetle. Others may reason from these facts as they think best; it is sufficient for me to have proposed the truth. I have not yet examined the eyes of the water Beetles, which I know can see both in water and air. I have seen the pyramidal fibres of the eyes in Crabs and Lobsters. All water Snails, as well as the human species, have three humours in their eyes, as I have described before at large. On this occasion it may also be observed that their eyes are sometimes multiplied. I proceed now to the pulmonary tubes, which are simple in the Worm, but are enlarged by the addition of bladders in the Beetle state.

These pulmonary tubes which in the Worm resembled the branches of trees without leaves, represent here in the Beetle a tree expanding its verdant and leafy branches: and here the autumn and winter of the miserable life which this Worm leads, is now in the perfect Beetle state changed into a pleasant and lovely spring and summer; with this only difference, that as the leaves of the trees have a plain and smooth surface, so these bladder in the Beetle are hollow, somewhat swollen, and expanded to an elliptical figure, and are somewhat swelled or blown up, Tab. XXIX. fig. IX. *a a*, by force of the air impelled into them. There is likewise this considerable difference, that out of the ends of these vesicles, where they rest upon their hollow pulmonary tubes, other pipes and ramifications *b b* again break out laterally, which, after they have been again dilated into vesicles, form air branches, vesicles and pipes: so that this division and process continues, until at length they terminate in very delicate, and as it were invisible pulmonary passages, which always remain round with open cavities. Hence the structure that occurs here may not be improperly compared to the third species of the Sea Wrack of Dodonæus. Nay, it is likewise observed that many tubes of this kind sometimes issue *c c* out of the same vesicle, which I have represented magnified above its natural bigness. Whenever the air gets out of these vesicles or bladders, they fall and become flat, and by the mutual contact of their sides, form a plain substance like the smooth leaf of a tree; whilst in the mean time the tubes affixed to them always remain open. The reason of this is, because these little branches rising from the principal air vessels consist of contorted and spiral parts, which, like the rings, made of silver thread or wire, and twisted round a small cylinder, always preserve their roundness. In the same manner this silvery web of pulmonary tubes appear to me to be compounded of a horny or bony pellucid matter, white as mother of pearl, and wound into spirals. These tubes are likewise lined on their inside with very delicate membranes, which keep their spiral form with all its windings in their situation. But where they are dilated into pneumatic vessels, they are entirely membranaceous, and besides, when viewed with a powerful microscope, are observed to be planted or set there with small studs or bosses like little grains. This is indeed a very agreeable object. Moreover, these vesicles are of a palish or white colour, and having no polish are nearly of the aspect of a Spider-web, or any thing of a like kind, covered with dust. The tubes on the other hand, are bright and splendid, and of a silver or of a pearly colour. See the explanation of these in Tab. XXIX. fig. x.

The reason of this difference between the pulmonary tubes of this creature, while it is in the Worm, and when it arrives at the Beetle state, seems to lie in the repeated change of their skin, whereof I have made mention before. The same thing is in some measure observed in the pulmonary pipes of the Silkworm Butterfly, for in this the tubes of the lungs, because they many times cast these internal skins, are every where very much dilated; though they have no distinct vesicles. However the matter be, since these white little parts, which are seen in the fat of the Nymph, ought to come principally into consideration here, I think this difficulty may be at length solved, if there were some more dissections made for that purpose. But I must reserve the doing of this to another time, and shall, till then, leave this matter uncertain. One may conveniently inflate or blow up the pulmonary tubes of the Beetle before described with a flexible leaden pipe, or the quill of the wing of some small bird: what in Holland we call the Cheese-bird has feathers admirably suited for this purpose; for the quills of this bird's wings are very perfectly hollowed throughout, especially if they be first strengthened by a small glass tube; and these parts thus distended afford a very beautiful sight.

Any one may see the pneumatic vessels, together with their tubes, without any dissection, provided he removes or takes the external wings, called the cases of the wings, from the body, and views them when turned to the light with a microscope. They even appear through the abdomen of the Beetle, and they may be likewise seen in the horny or bony and membranous part which covers the lower part of the body: but they are presented in the most beautiful manner between the plates of the external wings; for there they form innumerable and most singular figures. Three considerable branches of the wind-pipe commonly appear between these cases, that is, two on each side, and a third shorter in the middle; and out of these one may afterwards see the respiratory vesicles beautifully issuing and placed between them, in the same manner as I exhibit them here in a minute portion of that part; wherein two larger branches of the trachea, Tab. XXX. fig. I. *a a*, are represented on each side, and between them the pulmonary pipes issuing therefrom, together with their vesicles *b b b b*, out of which other pulmonary pipes arise, which are again dilated into vesicles *c c c c*; and these are again attenuated into pulmonary pipes, until at length they end in most minute and invisible filaments. In the inner part of the outer wings there may be also observed some other small points, projecting beyond the surface of the case or sheath, out of the middle of which issue oblong dispersed hairs. These I am confident are placed here to prevent the subjacent wing from being too much pressed, and at the same time to give it the means to fold and hide itself the more easily under the sheath. We have before shewn the use of these numerous tubes and pulmonary bladders; which is, that by their help the outer wings or cases of the wings may be expanded. I would likewise have it observed, that all these vesicles or bladders appear somewhat smooth, which may probably be owing to the contraction of the sheath or cases, which happens when the humours are exhaled, and the blood-vessels are closed or shut up.

The heart is much shorter in the Rhinoceros Beetle which I am describing, than it was in the Worm or Cossus; it is likewise more

more knotty; it is in ſome places dilated, fig. VII. *a a*, and elſewhere is again contracted *b b*, as I have ſhewn in a ſmall part of it: but I have not had opportunity to ſearch into it fully. I ſhall therefore now paſs to thoſe parts peculiar to the male and thoſe to the female; ſuch as the horn, the penis, teſticles, and ſeminal veſſels in the male; and the ovary, uterus, and vulva in the female; and after theſe are explained I ſhall conclude this hiſtory.

The parts peculiar to the male.

THE horns of the male Rhinoceros Beetle is formed of a tolerably ſolid horny bone, which makes it ſo firm, that one may bore or pierce even hard wood with it. It is crooked and bent backwards towards the bone of the thorax. It is of a black red colour, and ſo ſmooth and poliſhed on the ſurface that it ſhines like a looking-glaſs: and ſo likewiſe do the covering of the thorax; and the caſes or ſheaths of the wings, called alſo the outer wings: theſe are likewiſe parti-coloured, but approach more to red. The horn is ornamented with ſeveral ſmall holes impreſſed thereon. It is firſt membranaceous in the Nymph, and as it were full of a fluid; it afterwards becomes more firm, and at length acquires the full hardneſs we have named. And though this horn is flexible at the time of the creature's caſting its skin, yet in the ſpace of two or three days after this change, it becomes ſo wonderfully hard, that it is not only as firm as a cartilage, but even approaches to the nature of a bone. It is not, diſtinctly ſpeaking, ſituated on the noſe of the creature, but on the head, and may therefore be moſt properly called a production of the cranium or skull only, for it ſprings out of the ſubſtance of the skull where it lies over the brain. The male only has ſuch an horn by way of ornament. It is on the inſide hollow, as that of an Ox appears when ſeparated from the head, but its cavity is filled with no other matter than the dilated air-bladders; which, together with a multitude of tubes that adhere to them, are encloſed in it, and inſinuate themſelves even into its bony ſubſtance; hence the horn becomes much lighter, ſo that it may be carried the eaſier by the Beetle when it walks or flies. This inſect is therefore properly an Unicorn, for he has only one horn. It will not be improper to mention here, that if a Stag be gelt while young, his horns will never grow. This I have been informed by a curious and creditable gentleman. Wherefore theſe animals become in this reſpect like the female of this our Beetle, when their maſculine vigour is taken away.

With regard to the penis of this Beetle we are firſt to obſerve the nervous and the horny or bony part, Tab. XXX. fig. VIII. and IX. *a*; this laſt is as it were the prepuce, or rather a kind of ſheath for the penis: it is erected principally by its aſſiſtance, and is again drawn back into it when the occaſion is over. On the foremoſt ſide of this caſe are ſituated two little horny bones reſembling claws or hoofs *b*, which, forming a chink or crevice in the middle between them, are capable of being ſeparated from each other by the help of proper muſcles, in order to make a way, or afford a paſſage for the penis when it is erected. The muſcles for this ſervice are ſituated in the bony ſubſtance of the beforementioned ſheath, and are likewiſe articulated therewith. By the help of theſe two little bony claws the male in the time of coition fixes himſelf in the horny part of the female's vulva. Behind this ſheath is placed a nervous, ſoft, and very thick part of the penis *c*; wherein is placed ſuch a horny little bone as I have obſerved alſo in the root of the Bee's penis. Next follows the body or root of the penis *d*, which is nothing more than a ſmall tube, but it has a conſiderable nerve in the place where the vaſa deferentia and ſeminal veſicles meet. I have obſerved this nerve alſo in the water Beetle, and very conſpicuouſly in Bees. The vaſa deferentia *e e* are next ſeen on each ſide, and they contain a very white ſpermatic humour: they are indeed ſomewhat ſlender where they are connected with the root of the penis; but they become again dilated towards the middle, and thence become more ſlender where the principal teſticular veſſel is united with them on each ſide. The teſticles which diſcharge their ſperm through theſe vaſa deferentia, are of a very ſingular ſtructure in this Beetle. They conſiſt on each ſide of a ſimple vas teſticulare, which is about two feet two inches long. On one ſide I exhibit here entirely rolled out and unfolded *f*, whereby it appears at the ſame time, that the end of it is ſomewhat thicker, and, like the cloſe gut or inteſtinum cæcum, has no orifice, Tab. XXX. fig. VIII. and IX. *g*. But on the other ſide I exhibit this teſticle *h* in its natural condition; ſo that only the extreme end of this vas teſticulare appears removed from the maſs *i*. The vaſa deferentia and vas teſticulare have in this creature innumerable pipes and pulmonary veſicles: and by the aſſiſtance of theſe, the convolutions of the teſticular veſſels are firmly kept tied together; ſo that they cannot be diſengaged from each other, unleſs theſe pulmonary tubes are firſt removed, which cannot be done without continued labour and great patience. Between the vaſa deferentia are ſeen the ſeminal veſſels *k k*, which contain a ſpermatic matter of a duskier colour than that of the teſticles or dilated vaſa deferentia. And this ſeminal matter is doubtleſs generated and ſecreted in the veſicles themſelves, as is likewiſe the caſe in the human ſpecies and quadrupedes; in ſome of which the veſicles may be found diſtended

with

with feveral ounces of fperm. Each of thefe veficles is terminated by a fmall curled filament *l l*, which is indeed divided on each fide into fix fmall tubes; on the tops of which are depofited fo many very beautiful little glands *m m*. Thefe being united to thefe twelve tubes, by their means fend the feminal matter at the time of coition through the veficles to the penis. I exhibit fome of thefe glands alfo as they appear *n* when they are more fwollen in the middle than in the circumference, and are there filled with a pellucid matter, refembling that fubftance in a Hen's egg, which Harvey calls the colliquaneantum. But the fubftance which furrounds the middle part, is filled with matter like the white of an egg when beginning to concrete. Hence it is eafy to conclude, that the dusky fluid which is found in the veficles is generated therein, unlefs one fhould rather incline to think that it is thus changed in the veficles, which fhould have been firft proved. The middle part of thefe glandules is like a globe cut fomewhat fmooth on the top; but if the glandule be inverted *o*, this part appears entirely globular below, and the little branch of the veffel united to the veficles is there fixed in its center. This I exhibit fomewhat larger than the natural fize *p*, reprefenting in the fame figure the fubftance *q* that furrounds it, which contains a feminal matter much refembling the white of an egg. All round thefe glandules and feminal veficles are inferted numerous branches of the afpera arteria: one would almoft think that one faw the ciliary ducts in the human eye. The veficles have no communication with the vafa deferentia, which is likewife the cafe in Bulls and many other animals, and even in other infects, and as particularly in Bees. All thefe genital parts are perfectly white, except the veficles, which appear gray on account of the dusky feminal matter they are fwollen with, which is in fome meafure feen through them. Thefe little parts are fituated in the lower region of the belly, and are there found folded or wrapped one with another, in fuch a manner that at the beginning of the diffection one would think they could not be difengaged by any induftry. But patience overcomes all fuch difficulties. I obferve further, that infects differ very much with refpect to their genital parts, as is plain in the organs of Bees, the water Beetle, and others which I have occafionally delineated. Thefe parts are likewife very beautiful in the Hornet, though I have not yet fufficiently examined into their ftructure. I fhall now pafs to the ovary of the female.

The genital parts of the female Rhinoceros-Beetle.

THE female, which is diftinguifhed in this fpecies by having no horn, Tab. XXX. fig. x. *a*, on its head, fhews on diffection, its ovary fituated in the loweft region of the abdomen; but it is found to be fituated higher when it is diftended with eggs. In order to exhibit this the more clearly, I reprefent it, together with the head and gullet, and the ftomach *b*, which is very flender, and the inteftines *c*, together with the orifice *d* of the latter, which opens below and near the orifice of the ovary, as they are all naturally fixed among one another. The ovary *e e* confifts of twelve oviducts, fix whereof are fituated on each fide, but thefe afterwards meet in certain common paffages, which immediately afterwards form one fingle trunk, which may be called the uterus or rather the vagina of the creature. This trunk reaches to the extremity of the abdomen, out of which the female difcharges her eggs through the horny ring, which is formed like a crefcent, and is fhaggy *f* in the lower part. In one of thefe common ducts is here exhibited a perfect egg, and above are feen four other rudiments or imperfect eggs, adhering in three particular oviducts: the other three oviducts of this fide are empty or without eggs. On the other fide may be feen three more perfect eggs in the oviducts, which otherwife appear very clofely contracted in thofe parts, where I have delineated no eggs in them. I diffected this female the 17th of Auguft, at which time thefe Beetles have done laying eggs, and even the young Worms are by that time found. But if the extremity of the vagina which is fhaggy, be examined in the inner part, eight horny and bright red little parts, together with the paffages that then lead both to the vagina and to the inteftinum rectum or ftraight gut, are obvioufly feen. Under the vagina, not far from its external aperture, is feen an oblong or pear-fhaped bag, Tab. XXX. fig. x. *g*, which opens by a fmall tube into the vagina. When this bag is cut, a yellowifh matter is always found therein, which, after it is concreted, runs into fmall crumbles, if touched ever fo lightly: its yellow colour is feen through the bag. What ufe this fubftance is of I am yet ignorant. Above this bag are found two other tubes, which have clofe extremities, and unite in one fhort and narrow tube, which is likewife inferted in the vagina. One of thefe little parts *h* in the Beetle I diffected was pellucid, like a lymphatic veffel, but the other was very white *i*, nervous and hard. The ufe of thefe little parts likewife is altogether unknown to me. One may alfo fee here, in what manner all thefe parts are furnifhed with numerous pulmonary tubes, out of which iffue many pneumatic veficles or bladders, which likewife emit other tubes *k k*, *&c.* Thefe pipes connect the oviducts, ftomach, inteftines, and all the reft of the parts here delineated firmly together, fo that they cannot be difengaged but by repeated efforts. There is

a kind

a kind of entire trunk *l* of these pulmonary pipes, seen near one side of the common duct of the ovary; and other smaller branches *m* are seen about the stomach and intestines. Whilst I was engaged in drawing these pulmonary tubes, I purposely omitted to delineate the knotty vessels or vasa varicosa, which are much narrower and closer in the Beetle than in the Worm, for I could scarce have avoided confusion, if I had undertaken to exhibit to the life so many different minute little parts. It is also remarkable both in the male and female, that these little insects are now filled as much with pulmonary tubes as their Worms were before with bladders of fat.

Before I conclude this account, I shall exhibit, because it is pertinent to the subject in hand, five different exotic Rhinoceros Beetles, each of a peculiar structure. The first has a breast-bone, fig. II. *a*, which extends into an oblong tube, somewhat crooked about the anterior part, and at length split or divided in the extremity. The horn of its nose has also a sharp rising from the middle of it. In the second, Tab. XXX. fig. III. *a*, the breast is divided into two acute points, in the manner of a fork; and the horn, which like a proboscis, projects from the skull, turns itself in a peculiar manner, and is elegantly bent back between the teeth of the fork. This Beetle was brought from Japan. The breast-bone of the third, fig. IV. *b*, terminates in a short horn somewhat divided; from each side of which two other shorter crooked points project out of, or from the breast-bone: the horn on the nose in this is likewise very short, and terminates in two arched and sharp-pointed branches. This Beetle was brought from Brasil. I only exhibit the thorax or breast-bone of the fourth, fig. V. *c*, because it is in the body like the first, second, and fifth. This bone is pretty large at its origin, but it terminates in two short, crooked, obtuse points, and is adorned also on the lower part with some ridges projecting beyond the surface. The horn on the nose in this species is split as in the first species; The breast-bone of the fifth, fig. VI. *d*, is divided in various manners, it first emits a somewhat prominent obtuse point, afterwards it grows small, and then expands again into an eminence somewhat divided, and at length it terminates in two acute points or ends near the eye, one of which is considerably larger than the other. The margins or extremities of this bone have two ornaments like those which I mentioned in the fourth species. The other side of the breast-bone is divided and extended in like manner as that which I have here figured. The horn that rises from the nose is bent back like a segment of a circle against the prominence of the breast-bone *, and is obtuse at its extremity. A more accurate explanation of the parts of these several species will be given at the end of the work.

Now that I am near concluding this subject, I shall beg my readers to consider, whether the parts of these little creatures changed in so wonderful a manner, and formed with an art not inferior to the construction of the human body itself, can be formed by the assistance of heat and moisture, or be produced by chance from putrefaction? Or whether the infinite wisdom of God, and that most powerful hand, whose fingers made the heavens, and framed all nature, must be considered as the only instrument of their existence? I should indeed believe no one would presume to deny this. I shall therefore conclude this history, by observing that the Beetle is only a Nymph disengaged from its skin, and changed by accretion; as the the Nymph likewise is only a Worm that has changed its skin, and is altered or transformed in the same manner: hence these several states exhibit only one insect under three different appearances, which, after its miseries and mortifications, is advanced by degrees to a glorious and happy resurrection. The Worm leads a miserable life under the earth. The Nymph, deprived of motion, remains long as it were dead; but the Beetle, living at pleasure above and under ground, as also in the air, enjoys a superior degree of dignity, which however it has attained by afflictions and death, for without passing through these difficulties, it could never have come to that perfection. Here calm and serene weather succeeds a storm, and death opens the gates to life. Hence the apostle speaks most justly in respect to us: "I think "that the sufferings of our temporary state "are not worthy the future glory which shall "be revealed in us." We therefore, treading in the foot-steps of our Lord Jesus Christ, and having suffered all the miseries and punishments of this life, expect the reward. My spirit, in the mean time, raising itself with fervent zeal to God, cries out: "My soul magnifies the "Lord, because he discloses great things unto "me: he is powerful, and his name is holy.

The end of the wonderful history of the RHINOCEROS-BEETLE.

* We have in England two species of Beetles which are able to leap in a very surprising manner. In other insects this motion is performed by means of the legs, which are made of various lengths and forms adapted to that purpose: but these creatures do it by means of their thorax, which is also formed in the under part in a peculiar manner rising and elastick for that purpose: one of these is of a chesnut brown, the other of a greenish black. They both have flatted bodies and slender legs.

CHAP.

A particular treatise on the Culex or Gnat, which likewise belongs to the first method of the third order of natural changes called the Nymph.

As Ants, Bees, and Beetles are generated from a visible egg, in such a manner that an intermediate Worm first issues out of this egg; in the same manner a Worm or Vermicle, out of which the Gnat has its origin, is produced from the egg of a winged parent. As the several parts of the Worms out of which the just mentioned three insects arise and increase by degrees under the skin, and the creature having cast it, at length appear to our sight, all these incidents have place in the Worm and Nymph of the Gnat. But there is, notwithstanding, in this insect a considerable difference, which is, that whilst the Nymph of the Ant, Bee or Beetle, is without motion, and cannot change its place, this Nymph of the Gnat, on the contrary, has the power of loco-motion, and swims in the water; for this reason, it appears at first sight to approach in a great degree to the Nymphs of the second order.

On a just examination of the subject, this difficulty will be found, however, of small moment: for the Nymph of the Gnat, in reality, has no more motion in its legs than the other Nymphs of this third order; for it is never observed that it moves in the least its head, breast, horns, wings or legs; the contrary whereof is observed in Nymphs of the second order. For this reason, though the Nymph of the Gnat has so strong a power of moving from place to place, yet that is no obstacle to prevent our referring it properly and justly to the third, and not to the second order.

The true reason of the difference consists in this, the change which the tail of the Nymph of the Gnat undergoes, is not so remarkable, as that the Nymph should thereby lose the faculty of moving briskly. The tail is the only part, by the help whereof this Nymph changes place. The limbs and other parts in this Nymph, are in reality as immoveable as they are in the Nymphs of Ants, Bees and Beetles. And even these Nymphs are not wholly deprived of the power of moving their tail, as is evident in the Nymph of the Rhinoceros-Beetle just described; for this can, by the motion of its tail turn itself a little in its terrestrial habitation. But in the Nymphs of Ants and Bees this is not observed, until they have passed the greater part of the Nymph state, and are very near changing their skin. Having therefore removed this difficulty, which might appear more considerable than it is to those less acquainted with these changes. I shall proceed to give the particular history of the Gnat and its Nymph; from the particulars of which all those things which have been said in the preface will be better explained and easier understood.

The Gnat is produced out of a very small egg, which is exposed or cast into the water by the parent Gnat, when she is engaged in laying her eggs, and in a few days this produces a very small Vermicle or Worm *. I was first informed that the Gnats sprung out of the water by the curious and learned Mr. Duissen, a very vigilant protestant minister at Saumur in France, who had observed it in his kitchen garden, where there was a stone bason with water in it, out of which he saw plainly that Gnats arose at a certain season.

Afterwards, on my return to Holland, I found the Worm of the Gnat swimming in water, and immediately took its figure. Hence it happened, that when I saw it in the admirable figures of Dr. Hook's micrography, I immediately knew it, since that very learned English gentleman has delineated it with the greatest accuracy. But this celebrated writer does not seem to me to have examined the tail of that Worm with sufficient attention. I shall observe further, that the Nymph of the Gnat has been somewhat improperly exhibited by him, unless he had some other species of this insect. This is the more probable to me, as I find there are various Nymphs of Gnats, as well as many kinds of the Flies themselves.

In Tab. XXXI. fig. IV. I exhibit in its natural size the Worm out of which the Gnat is produced. The same is likewise represented in fig. V. magnified by a microscope, and thus it presents to the eye very obviously the construction of its breast and body. It may be likewise observed here, in what manner it raises itself to the surface of the water by the help of its tail, and also the construction whereby it is divided into the head, breast, body and tail.

In the head, which lies sunk under the water, I have shewn in this figure various particulars particularly the eyes, the horns, and the lower part of the mouth. The eyes are black *a a*, and have a smooth and polished surface; nor are they divided like a cluster of grapes, or by an hexagonal network, as in many insects, but are of a figure somewhat lunated or like a crescent. The horns are shaped not unlike the collar-bones, Tab. XXXI. fig. V. *b b*, in the human species, and are furnished with hairs towards their ends. The opening of the mouth

* There is not in all the insect world a creature more happily suited to shew the several operations of life than this. A moderate microscope discovers to us very clearly what passes within its transparent body. The creature is at first greenish and somewhat dusky, but as it grows towards the change, it becomes pale and greenish. At that time the beating of the heart, and the motion of the stomach and intestines are perfectly seen, and the two principal pulmonary tubes may be traced along their course very clearly.

is likewise shewn here *c*, appearing like a blackish triangular spot. We may likewise distinguish by the microscope seven other little parts of the mouth, whereof I exhibit three, as well above the mouth as at its sides; but the seventh, which is somewhat brown, is observed to have its two bases placed near the thorax, and reaching to the eyes. This little part is somewhat whiter in the middle, and grows browner a little lower near the mouth, but in the anterior or fore part, it appears to be formed like the nails of our fingers, or the scales of fish. Where this little part terminates with its brown curvature or winding, almost in the middle or lower region of the head, I exhibit the first of the three pair of little parts already named. This pair is of a triangular figure, on account of the hairs wherewith their inner side is surrounded. About the end of this follows another pair of the like little parts, the beginning of which are horny or bony, but the extremities are hairy. Below these again are seen a third pair of little parts which are somewhat thicker and more shaggy, and extend to the hairs of the horns. These three pair of little parts are, properly speaking, articulated bristly hairs, which the Worm of the Gnat makes use of to direct the food to its mouth. I have before observed something like this in the hermit Crab, in which I have described many little parts of a somewhat like kind. The mouth of this Worm is in the fore part beset thickly with hairs, which are all of equal length, and are placed equally distant from one another: this is shewn at the letter *c*.

In the thorax are certain regular divisions *d d*, which are produced by the growing and extuberant joints of the legs and wings of the Gnat within. Hence I can shew even in this Worm all the limbs and parts of the future Nymph, and of the perfect Gnat lying under the skin, as I shall do on a succeeding occasion in the Worms of Bees, and shall thus exhibit an example applicable to all other insects belonging to this first species, or method of the third order of natural transformations. Afterwards, when I come to the second method of the third order, I shall present to the eye a kind of similar instance on the diurnal Butterfly. We may likewise further observe how the thorax of this Worm is distinguished with furrowed lines, and beset on each side with bristly hairs, many issuing together as it were out of one center.

The belly is divided into eight annular sections, Tab. XXXI. fig. v. *e e*; to which, if you add the shaggy extremity *f* of the tail, and that part of it which is likewise strengthened *g* with the bristly hairs, and is extended by the Worm above the surface of the water, ten rings must be reckoned in the whole. In that part of the tail which is seen *h* above the surface of the water, there appear certain black spots, and some depressions or holes, as also many bristly hairs. But here we must take particular notice, that whenever the Worm, swimming in the middle of the water pulls down the part of the tail just mentioned under the water, that part never becomes wet. Therefore, when the Worm wants to rest, or cease moving, it immediately goes up to the surface, and there, by means of its tail, suspends itself almost in the same manner as we see a little glass figure of a man hang pendulous in a glassy bubble in water. This is done the easier by this Worm, because its tail always remains dry: hence it is also observed that as soon as this appendage of the tail has again emerged to the surface, the water immediately flows away from it on every side. And one may distinctly see that a kind of bason or hole is by that means impressed on the water, when the body of the Worm gravitates downwards; the water not being able to penetrate into the dry tail and its depressions, is stopt in its circumference: and therefore the Worm, in regard to the extremity of its tail, very beautifully swims in the water in the manner of an empty hollow glass. The like effect may be likewise produced by art, if a needle be drawn through a cork and put into the water; for the cork will then swim on the water, and in like manner make a considerable depression in the surface.

Near the extremity of this tail I exhibit some bubbles in the water *i*; these are frequently seen, and they arise from the air which the Worm can at pleasure emit there out of its body. I have seen that the Worm, in order to draw in the air, has raised its head out of the water. When it has happened that the tail had lost its dryness, and the Worm by this means can no longer suspend itself on the surface of the water, which is the case when it is bruised or handled too roughly; I have on these occasions observed, that it put its tail in its mouth, and afterwards drew it back together with its hairs. In this method of proceeding the insect resembles water fowls, which, by drawing their quills through their beak, prepare them in such a manner that they can resist the water. They secrete this fat matter by means of a double gland which they have in their rump, in which this oil, which strengthens the wings against the water, is generated and excreted, and they thence take it into their beaks. I have sometimes covered anatomical instruments of steel with this matter, in order to keep them from rusting, and have found that the steel continued perfectly defended from rust by means of it; and I think it would have greater effect, if one had a great quantity of it boiled and properly managed.

As this whole insect is pellucid, I have here exhibited the two transparent pulmonary tubes which appear in the middle of the tail where it floats in the water. These arise from the body near the thorax, and contain, Tab. XXXI. fig. v. *k k*, in them the quantity of air whereby the bubbles are produced. This insect therefore breathes at its tail, in the same manner as the Worm of the Gad Fly. But this tail is not so absolutely necessary for the Worm of the Gnat, that it cannot live without it. It only serves

ſerves for its conveniency, and by its powers enables the Worm to reſt or hold itſelf ſuſpended on the ſurface of the water. Hence it is, that the tail is entirely deſtroyed and thrown off when the Worm caſts its skin and is changed into a Nymph.

As to the other part of the belly or tail, whoſe extremity is likewiſe ſhaggy, with briſtly hairs, I exhibit about it ſome ſmall lumps *l* of an earthy matter, which fall into the water and there melt away by degrees *m*. Theſe are the excrements voided from the inteſtines. We may likewiſe obſerve here the inteſtines themſelves, which contain theſe fœces, and are ſeen through the tranſparent belly, ſituated between the pulmonary tubes *k k*, and at length terminating in this other extremity of the belly which is the real tail. It is very ſingular, that in this Worm, not only the motion of the inteſtines, but alſo the propulſion of the excrements in them *n* may be ſeen through the integuments of the body. This motion of the inteſtines, the never-enough celebrated Dr. Hook firſt diſcovered. I obſerve likewiſe that theſe pellucid inteſtines appear ſometimes white, ſometimes black, and are ſometimes divided into little knots. This variety ariſes from the contents and excrements being more or leſs changed in them. Laſtly, I likewiſe ſhew ſmall hairs in the eight rings of the abdomen, three in ſome, and in others four, and alſo the ſquamous or ſcaly windings and conſtructions thereof.

When this Worm is arrived at its full growth, and its limbs having attained their due perfection, are ſwollen or filled with blood and humours, it throws or caſts off its old skin, and expoſes to open view all its hitherto hidden limbs and parts; this is when it is changed into a Nymph, which is delineated in its natural ſize or bigneſs in Tab. XXXI. fig. VI. and in fig. VII. as it appears magnified with a microſcope. In the latter deſign, the head, breaſt and belly may be more diſtinctly ſeen than in the Worm; nay, and the eyes alſo, and the horns, the trunk, the legs and the wings. All theſe parts are however fluid like water, and muſt in due time evaporate this moiſture in the water, to ſuch a degree as to acquire due firmneſs.

Leſt the delineation of theſe parts ſhould be obſcured by annexing letters to them, I ſhall ſhew them all in a leſs finiſhed figure, which I have added for that purpoſe. Before I begin, it muſt be particularly obſerved, that the head, which before in the Worm hung downwards towards the bottom of the water, is always raiſed upwards in the Nymph, and is likewiſe, by means of two tubes, ſuſpended on the ſurface of the water, in the ſame manner as the tail of the Worm was before. Hence, as the Worm then drew the air through the tail, being changed into a Nymph, it now breathes the air with its head through the tubes juſt now mentioned. Hence it is alſo obſerved, that the tail which in the Worm was protended upwards, lies in the Nymph ſunk under the water; and this is indeed a remarkable change in the inſect with reſpect to its manner of living.

One might take theſe tubes in the head for the horns which the Worm had before, and which are now, after caſting the skin, dilated and adapted to another uſe; but thoſe horns were ſituated nearer to the foremoſt parts of the head. The tail is likewiſe upon the change of its skin conſiderably altered; it has acquired in this ſtate a beautiful feather, to ſerve as a rudder, by the help of which this Nymph moves freely from place to place; and ſwims in a quite another manner than it uſed to do when it was in the ſtate of a Worm. Dr. Hooke has alſo obſerved this change of the Nymph, in reſpect to the manner of its moving and ſwimming, as appears from his Micrography. In many inſects, nay, particularly in theſe which belong to the ſecond mode of the third oder, it is obſerved that when they are changed into the Chryſalis they have a motion in their tail, though all the reſt of their body become wholly immoveable, as is alſo the caſe in this Nymph. We have fully treated of this in the beginning of this chapter.

On one ſide of the head in this deſign is ſeen an eye, Tab. XXXI. fig. VIII. *a*, covered a little on the upper part with a membrane, which inveſts the proboſcis or trunk, and this eye, is now divided into hexagonal and globular diviſions. Above this appears to be ſituated one of the antennæ *b*, divided into ſeveral black knots which are ſo many joints. The trunk *c* which is the Gnat's ſting, and which partly covers the eye, is placed with its ſharp point between the legs and wings. The legs *d d d d* are in a wonderful manner twiſted and bent, but eſpecially in the hinder part; and they are hidden between the wings, and appear plainly through the tranſparent ſubſtance of the latter. This I here exhibit delineated, that both the wing of this ſide may be ſeen, and alſo the membrane that inveſts it *e e*, and which is placed above the legs. The body is divided into eight rings, on which ſome of the hairs, that have changed their outer covering *f f*, are obſerved to reſt. Through the middle of the whole length of the body appears a beautiful border or riſing verge *g g*, which I could ſcarce diſcover in the Worm of the Gnat, nor have I afterwards found it conſiderable in the perfect Gnat itſelf. The tail, which hangs down, has, as I obſerved, a moving jointed fin *h*, by the help of which the Nymph removes from place to place. In the upper parts of the head are ſeen the tubulated horns *i i* before deſcribed, by means of which the creature, while in this ſtate, hangs and breathes on the ſurface of the water; but by the help of this conſtruction the Nymph is now better prepared to be changed into a Gnat after caſting its ſkin. This inſect, while in the Nymph ſtate, has no certain colour; for, upon its change, it grows white, and afterwards becomes ſomewhat green, and at laſt it approaches to black.

After this Nymph has lived ſome days, moving itſelf backwards and forwards in the water, and its tender limbs are ſtrengthened, it burſts and caſts its ſkin in the middle between thoſe two horns or tubes, by the help of which it was before ſuſpended on the ſurface of the water; and after this, on account of the lightneſs of its body only, it remains on the ſurface, until its wings are expanded and dried with air; then the Nymph having aſſumed the form of a Gnat flies away, leaving its caſt ſkin ſwimming in the the water, where it inſenſibly decays.

The Gnats of this ſpecies *, which are beſt of all known in Holland on account of their miſchievous trunk or ſting, are eaſily diſtinguiſhed into males and females. I exhibit the male in Tab. XXXII. fig. I. and alſo a microſcopic view of it in fig. II. Between this Gnat and its Nymph there is no other difference, except that the limbs are diſpoſed and placed in a different manner in the Nymph from what they are in the perfect Gnat. Hence, as the head, breaſt, belly, &c. may be ſeen and unfolded in the Nymph, we may diſtinguiſh all theſe things in the Gnat itſelf, but much more accurately, for the external ſkin of the Nymph, which prevented the more diſtinct view of all theſe parts, has been now, upon the laſt change, thrown off.

In the head of the male Gnat, I particularly exhibit, in the enlarged figure, the eyes, horns, and trunk; as alſo two other parts placed near the trunk or ſting, between or under which the latter is properly placed: the eyes *a a* conſtitute the greateſt part of the head, as is the caſe in many other ſpecies of inſects. They are of a greeniſh colour, and they form as it were an hexagonal piece of network, the diviſions whereof riſe in a globular figure. Near the eyes I repreſent the horns *b b*, which ariſe as it were out of two yellowiſh fleſh-coloured little globes, and are beautifully divided into twelve black knot-like joints, which are ſurrounded with hairs like tender flaxen threads. Toward the extremity of each of theſe antennæ is ſeen a circle, conſiſting of ſix hairs placed in a circle; above which appear the extreme ends of the horns ſurrounded or covered with yet ſmaller hairs. As to the other two long and crooked parts, between which the trunk or aculeus is obſerved to be ſituated *c c*, I find them divided into three joints, beſet with hairs toward their extremities, and moreover covered every where with a kind of browniſh feathers, which reſemble, as the feathers of Butterflies do, the little ſcales of fiſhes.

The trunk is of the ſame colour, and is adorned *d* with the like ſcaly little feathers, but it is not divided into joints, being immoveable in the middle; though there are plainly ſome diviſions toward the end of it; and it is there likewiſe near the end regularly ſurrounded by five hairs on each ſide of it. On full conſideration of the whole, the part before deſcribed, and which we uſually call the trunk *e*, the aculeus or ſting of the Gnat, is nothing more than a ſheath or caſe of the real ſting *e*, which is repreſented in this figure only projecting, or as if thruſt, out of it. This ſting is provided with ſo ſharp a point, that I could never obſerve the leaſt breadth therein, with the beſt microſcopes that I uſed in the year 1688. If you put the edges of the ſharpeſt razors, or the points of the fineſt needles and lancets before the microſcope, you will eaſily ſee that they have viſible breadth, and appear blunt, ragged, and dull. I do not find this ſheath in all Gnats; and this is the caſe in that ſpecies deſcribed by Goedaert, the ſting of which I ſhould incline to think is very ſhort, and lies rather in the mouth than in any ſheath or caſe; ſo that the ſame thing ſeems to obtain here as in the Louſe kind, the ſheath and trunk of which are alſo diſcovered with difficulty, though theſe little creatures prick or ſting vehemently, and give us great trouble by ſucking our blood.

Thus I obſerve, with reſpect to other inſects, that there is great difference as to their ſtings and trunks; ſome of them have their proboſcides eight times longer than others, beſides that the conſtruction differs greatly in both. But I have elſewhere ſaid enough on this ſubject, when I treated of the ſwift Butterfly, which is repreſented in the hiſtory of the Rhinoceros Beetle, Tab. XXIX. But when I come to the Gad Fly I ſhall, from the obſervations I have made on the ſting and trunk, offer ſome reaſons why many inſects that feed on blood, ſtill preſerve life, through deprived for a long time of the blood wherewith they naturally nouriſh themſelves. This queſtion may certainly ariſe with reſpect to Bugs, Fleas, and ſeveral ſuch inſects, and alſo in regard to the Gnat kind. I now return to the ſubject and ſhall give a more full explanation of the trunk of the Gnat.

The caſe or ſheath of the ſting, as I have already obſerved, is immoveable in the middle, but where it is united to the head it appears to be jointed. If one diſſects it under the microſcope, and very quickly breaks it off at a little diſtance from the head, or cuts it, Tab. XXXII. fig. III. *a*, in its circumference, but in ſuch a manner, as at the ſame time to draw this broken caſe of the ſting from the ſting itſelf, which is placed on the inſide; this way at length the aculeus is plainly ſeen naked and diſengaged from all impediments, in which ſtate it could not be viewed before. When I firſt made this experiment, I thought I had diſcovered the whole aculeus in this manner: for I obſerved an acute pellucid little part of a bright red colour *b*, which conſiſted of a horny

* We have in England three very diſtinct kinds of Gnats: the largeſt of theſe has brown eyes, and a black and white body; the middle kind is altogether brown: this has the moſt miſchievous bite of any. The third or ſmaller kind has a red breaſt; this alſo bites ſeverely. The Worms of all theſe are alike in form, and, what is very remarkable, they differ little in ſize. We have beſide theſe a multitude of diſtinct ſpecies very ſmall, which are, in the fen countries, very troubleſome.

or bony matter, and was moderately ſtrong and yet flexible. But upon examining this little part afterwards with a larger magnifying glaſs, I obſerved that there was a conſiderable aperture juſt below its ſharp point; and I alſo obſerved two little drops of a real liquor, at ſome diſtance from each other, lying in the middle of this little part, as in a little hollow tube. As I was attempting to expreſs or get out this liquid under the microſcope, it happened, contrary to my expectations, that I broke that little part. This accident had great advantage, for on the inſide of this little part I then diſcovered five diſtinct aculei or ſtings, and conſequently thus found the whole conſtruction of the aculeus.

I obſerved that two of theſe aculei which were hidden within the tubulated little canal of the general thing were, much more ſlender, Tab. XXXII. fig. III. *c c*, than the three others, which appeared thicker and ſtronger, *d d d*. I likewiſe obſerved that they were ſomewhat broader where they were articulated with the head, but that they afterwards became ſmall, and that they were finally conſiderably extended, before they terminate in their delicate and fine points. All theſe aculei were of a delicate ſmooth ſurface, but in the middle they were ſomewhat thicker and more diſtended, ſo that in that part they appeared of a browner colour, exhibiting to the eye within a pellucid bright redneſs: but they conſiſted of a flexible horny or bony matter like that of the little canal which contained them. I could not diſcover any cavity in them, though there ſeemed to be ſomething of this kind in the larger; for when theſe were examined with a very acute glaſs, they curled and continually moved about: this, I thought, muſt be attributed to the evaporation of the humour incloſed or contained within their ſubſtance. I could by no means, however, obſerve any other mark of their being hollow on the inſide.

As to the uſe of theſe five aculei, they ſeem only to ſerve as ſo many very ſharp lances to enter the pores of the skin, and afterwards to retract or draw themſelves back into the inward caſe wherein they are kept: but then I ſhould think that the acute and hollow extremity of this caſe is certainly introduced into the wound, and by means thereof the Gnat afterwards ſucks the blood, which, running or aſcending by ſuction between theſe ſharp parts, is at length conveyed into the body of the inſect. Hence there appears almoſt the ſame uſe of this ſheath as there is of the ſilver pipes uſed by our ſurgeons, through which they paſs their lancets when they are about to open ulcers that lie deep between the jaws, and are careful to wound no other parts but thoſe they are to cut. The reaſon why nature hath made five aculei for this purpoſe, is, I confeſs, beyond my comprehenſion, unleſs one ſhould incline to think that by the repeated agitation of ſo many things in the womb, the blood is better prepared to aſcend through this long and moſt ſlender tube wherein thoſe ſtings are hidden.

I am firmly perſuaded that when the Gnat has no opportunity of drawing blood out of animals, it ſucks, with the help of its caſe, the juices of flowers, plants or fruits, being content with feeding on the latter when it wants the former: indeed, by what other means could it ſupport itſelf, when it lives in the fields and woods? I would not now preſume to affirm for certain, whether, when I firſt communicated to the public the figure of the Gnat's trunk, not knowing then that it had five ſtings, I ſaw one or more ſtings projecting or hanging out of its caſe; but I am not certain now that theſe five ſtings, viewed ſideways, do not appear broader in the fore part next under their points than elſewhere.

After I had made the obſervations already mentioned on the ſting of the Gnat, I often afterwards obſerved in the dead Gnats, that all their ſtings were broken off from their caſe, and appeared without the little tube, without my aid. And hence I began to conſider, whether theſe integuments of the five ſtings reſemble or not the ſheath or caſe of a Bee's ſting, and only or looſely contain the real ſting, as a ſcabbard open on one ſide might hold a ſword. But, notwithſtanding the repeated pains I have hitherto taken to diſcover the truth in this matter, yet I could never find out any mark of ſuch a ſtructure. I therefore think I may ſafely maintain that both the caſe of the ſting and its inward pipe are two diſtinct and entire integuments, the exterior of which contains the little tube, and the interior, which is the little tube itſelf, contains the five ſtings.

It has ſometimes happened, that upon examining theſe things in other ſpecies of Gnats, I have obſerved that, like the ſtings of Bees, they were provided with a kind of crooked claws, or were at leaſt ſerrated on their ſurface. But this I had not the good fortune to ſee when I was engaged in drawing and finiſhing the figures of theſe parts from the preſent ſpecies; only I thought I once ſaw ſomething like it through the common microſcopes, and therefore thoſe who are fond of microſcopes, muſt take care not to confide in one lens or glaſs only, and muſt not always view the object in the ſame manner and ſituation, for by this means many errors ariſe. In the third figure above mentioned is likewiſe ſeen the neck, Tab. XXXII. fig. III. *e*, of the Gnat, and the head *f* placed thereon, in which the eyes *g g* appear, as alſo the antennæ cut off *h h*, and the articulated ſetae *f* or briſtly hairs *i i*, which are cut off above the ſtings.

As to the thorax of the Gnat, it carries the legs and wings, and alſo two little parts like hammers, and of an oval figure. The legs are of a browniſh colour, and conſiſt of ſeven joints, fig. II. *f f f f*, which are larger in the hinder that in the fore legs: but beſides theſe, the extremity of each leg is likewiſe armed with

with two claws. Moreover, the legs of this insect are all over covered with ſcaly little feathers, between which appear ſome blackiſh ſetaceous hairs.

The ſtructure of the wings *gggg* is ſo beautiful, that nothing can, in a manner, be invented more ingenious or artificial. They conſiſt partly of pulmonary tubes, and partly of delicate membranes, which are perfectly pellucid. They are of an oblong form, and of a glaſſy colour; but they are obſcured or ſhaded by a very great number of ſcaly rhomboidal figures, which are a vaſt ornament to them. All the membranes of the wings are interwoven with pulmonary tubes, which run through them like ſo many veins and nerves; and upon thoſe pulmonary tubes, which are conveyed out of the body into the wings, are fixed theſe oblong and broad feathers for the ſake of ornament. The ſame conſtruction is ſeen alſo in the beginning, middle, and circumference of the wings, and is a very agreeable ſight. In order to make this ſtructure clear or more evident, I here exhibit the wings ſomewhat larger, in proportion to the other part of the Gnat, than they were formerly. But if theſe wings were repreſented as large as they can poſſibly be magnified by good glaſſes, the divine miracles that are preſented to us therein would amaze all mankind.

We ſhould then diſtinguiſh clearly that every ſeries of the little feathers before deſcribed, likewiſe reſts on a ſtalk or tube, by means of which, it is united to the pulmonary tubes: and alſo, that ſome of the feathers are here and there larger, ſhorter, or broader, and placed in a quite different manner from the reſt, as far as regularity and beauty would admit. If broken feathers chance to occur any where, their quills will be found there ſtill fixed in the pulmonary tubes. The ſtructure of the little feathers would ſhew itſelf very admirable in this caſe, for almoſt all of them are interwoven with ſix regular little ribs like ſo many nerves, each of which conſiſts of a great number of regular globules. This is ſeen more clearly by the help of a powerful microſcope; all theſe little feathers being likewiſe tranſparent, though they are not altogether ſo clear as the membranes of the wings.

Further we may obſerve, in what a wonderful manner the very membrane of the wings is conſtructed in this creature, for it appears under the microſcope beſet with many prominent papillæ or little riſings. If this part be viewed by help of the moſt powerful microſcope, it will be diſtinctly ſeen that all theſe papillæ are ſo many crooked, curled, pellucid little tips or points, of moſt delicate, long or extended papillæ. In all this the omnipotence and wiſdom of God ſhines brighter than the meridian ſun. All theſe things cannot be expreſſed in the ſmall compaſs of a ſingle figure. I have therefore exhibited upon this membrane of the wings, only a few out of the great number of theſe inflected and ſharp-pointed papillæ in the form of points. Nay, I would venture to aſſert, that however good the microſcope made uſe of is, yet one cannot ſee theſe papillæ diſtinctly, unleſs we firſt tear a part of the membrane of the wings carefully for that purpoſe; for the ſharp little tops or points which I have here mentioned, are only to be ſeen when all impediments are moſt carefully removed.

The malleoli, Tab. XXXII. fig. II. *h h*, or little hammers fixed to the breaſt, whereof I made mention, are of a ſomewhat irregular ſhape, and at their extremities are conſiderably dilated: they are there ſmooth and of a whitiſh colour. I have obſerved ſuch malleoli almoſt in all Flies which have only two wings. The ſurface of the thorax alſo ſhines a little, and being covered in a manner with red briſtly hairs, inſtead of feathers, it is likewiſe adorned with a red colour.

The belly is divided into eight rings *k k*, in the ſame manner as I have exhibited in the Worm and Nymph. All theſe diviſions are likewiſe as viſible in the perfect Gnat, as in thoſe ſtates lately mentioned. I further, obſerve that the belly and tail are every where covered with feathers, which are black in ſome places; and this is the reaſon that the belly and tail appear divided as it were by black rings. The other little feathers intermixed with the former are of a white or yellowiſh colour, and are wholly tranſparent. Moreover, the whole belly is every where covered with fine hairs, the extremities of which curl, and ſeem to be in ſome meaſure entangled in one another, though in reality they are not.

I alſo repreſent the head of the female Gnat, fig. IV. magnified, which, in reſpect to the ſtructure of the horns, differs from the male's head *a a* extremely. Thoſe little parts of the head alſo, between and under which the ſheath of the ſting is extended, are much ſmaller in the female, and diſtinguiſhed with greater difficulty *b b*. The horns in this ſex are alſo divided as it were with twelve parts, and they are regularly covered with browniſh hairs and little feathers. The ſheath of the ſting *c*, and the other little parts are of the ſame ſtructure, and have the ſame integuments that I have before deſcribed in thoſe of the male. Laſtly, that nothing may be deficient, I likewiſe exhibit the female herſelf in her natural ſize, in fig. V. I have not yet accurately inveſtigated the internal parts of the Gnat, and therefore ſhall ſay nothing of them here.

I have occaſionally obſerved many diſtinct ſpecies of Gnats, but their principal difference conſiſts in this, that ſome of them have and others have not a ſting or trunk, and therefore ſeem to be harmleſs. They likewiſe differ conſiderably among themſelves in reſpect to their magnitude, colours, and food; the place wherein they live, and the manner wherein they are produced; and in ſeveral other particulars worthy

worthy attention. At prefent I fhall fay nothing more of thefe infects, being already too much fatigued with obferving and defcribing thofe particulars, which I have hitherto advanced. I fhall therefore conclude this treatife, and proceed to the hiftory of Bees.

A TREATISE on the

HISTORY of BEES;

Or an accurate defcription of

Their origin, generation, fex, œconomy, labours and ufe.

O come hither, and behold the works of God: how wonderful he is in doing towards the children of men. Pfal. LXVI. 5.

INTRODUCTION.

ALTHOUGH the majefty of the immortal God is in its nature inacceffible to mortal eyes, his eternal power and divinity are moft clearly and evidently feen in all created beings: fome creatures, however, prefent the invifible God to our contemplation more plainly than others, as will appear from the fubfequent treatife. Since, therefore, the moft wife and great God has been gracioufly pleafed to blefs and crown my indefatigable and affiduous labours with fome degree of fuccefs, I hope that his infinite power and immenfe wifdom, as well as our own weaknefs, will be thereby made clearer than the light at noon; fo that whoever perufes this treatife, may find matter enough of wonder, and be led to proclaim and admire the magnificence and wifdom of God, and to blefs his inexhauftible bounty. If thefe pages, which only exhibit as it were the fhadows of things, and extremely defective defcriptions of the fecrets works of God, that are impenetrable and impoffible to be fully inveftigated, fhould direct the reader to this true ufe of the refearches, I fhall think the pains I have taken, not only recompenfed, but alfo fufficiently profperous and bleffed by the divine grace.

If any one accurately confiders the difpofition and ftructure of the fmalleft and largeft animals, and compares them one with another, he will fee that they agree not only in the above mentioned particulars, but alfo in that they fpring from like principles, which are eggs of their parents, as well in the fmalleft as in the largeft animals: and as thefe eggs increafe and are perfected, as it were from very fmall and almoft invifible points, they, in the fame manner, come to the full period of their increafe in the fmalleft animals as in the largeft. Nor is there any creature excepted from this univerfal law of its origin. Since man alfo, the moft noble of all creatures, and who is a rational animal, has his origin or beginning from an egg, and therefore cannot, in refpect to his firft principle, prefer himfelf to the fmalleft infects, or, with regard to his natural difpofition and ftructure, affume to himfelf any fuperior dignity, in preference to the moft mean and contemptible creatures the Loufe or Mite. That this is moft certain in regard to the human fpecies, I have learned from experiment, in the year 1667, as did alfo the celebrated Van Horne. This may be feen in my book intitled, the miracles of nature. Further, it deferves notice, that as to the principles or rudiments of fmaller as well as larger animals, the former are more confpicuous, and more clearly difcernible in their firft ftate than the latter. And further, fince God hath prefcribed certain limits of magnitude to the fmaller animals, beyond which they cannot increafe, and which limits are probably fituated in the peculiar ftructure, or from the weaknefs of the heart, by the power of which all the other parts muft be extended againft the gravity of the atmofphere; the fmall animals, therefore, while in embryo, may be much more perfect than the larger.

To come nearer to my purpofe; as I propofed in my book of infects publifhed in the year 1669, at fome other time to treat exprefsly on the ftructure of infects, and in that work to give the particular hiftory of Bees; faying, by way of anticipation, that the king, as commonly called, was a female, the drone a male, and that the common Bees belonged to neither fex; I fhall, to keep my promife with the publick, now treat particularly of the ftructure, difpofition, and principles or rudiments of thefe three creatures, which are different in themfelves, but of the fame fpecies. I fhall alfo occafionally interfperfe fome other obfervations on the parts of fome other infects, the whole conftructions of which I fhall, with the divine favour, at fome other time defcribe more at large.

On

On the twenty-fecond of Auguft 1673, I opened a Bee-hive, after the Bees had fwarmed, I found fome thoufands of common Bees in it, fome hundred drones, and one king. But as, properly fpeaking, neither king nor drones are to be found in the hives, as has been already obferved; and fince it happened, through a very great and inexcufable error, that thofe wrong names were given to thofe creatures, I would therefore here in the beginning inform the reader, that through this whole treatife I fhall call that pretended king by the name of the female Bee; and to that which is commonly called the drone, I fhall give the title of the male Bee, and the common Bees, I fhall, for diftinction's fake, denominate working Bees: I fhall alfo in the following pages, fhew the very clear and evident reafons which have induced me to make this innovation.

When I had opened and deftroyed a hive at the time above-mentioned, befides the males, females and working Bees, I found therein three different fpecies of cells, or little houfes of the infects, which are called by the general name of honey-combs. In fome hundreds of thefe cells the males were fed and grew, in fome few, females were generated; and in the reft, of which there were fome thoufands, the common Bees were nourifhed, brought up, and finally changed. The cells of the males and females were are this time empty, but the cells of the common Bees, though they feemed for the moft part empty, were many of them really full and covered with wax. When I broke thefe cells open with a fmall needle fixed on a skewer, I found fome of the Worms of the Bees placed upright without any motion. In fome other cells that were covered in the fame manner, there were Nymphs or Worms of Bees, which, by due accretion, had already acquired the form of Bees, and were to be let out from thence. In others I found honey. The reft of the cells were open, and not covered or fealed up; and fome of them had eggs, others contained Worms very lately hatched out of their eggs, and provided on every fide of them with food: others again had larger Worms; and finally, others were arrived at their full bignefs. Thefe are called the offspring or ftock, by the keepers of Bees in our country, and they had yellow excrements under them.

In the middle between thefe eggs and the ftock, were feen fome little cells alfo fealed up, which, when I opened, I found filled with honey; for the Bees never leave any place empty in their hive, but as foon as any Worm is changed into a Bee, they immediately fill its cell with fomething elfe. Therefore, if the combs in the upper part of the hive are firft emptied of the young Bees, they firft put their honey into them; but if thofe in the combs in the middle of the hive become mature before the others, they firft fill them with honey: and laftly, when the combs of the loweft part of the hive are emptied, they in the fame manner fill them before the others with honey: but they afterwards carry the honey repofited there to the upper part of the hive. This Clutius obferved, but I have not yet feen it. The Bees proceed in this manner, when the year is fruitful, in order to fhorten the time, fo as to enable them to gather the more honey, or when they are more numerous in the hive; for then they immediately lay the honey as foon as there is room, and afterwards, when the time of making honey is paft, they carry it elfewhere.

This hive, therefore, as a common and fraternal habitation, contained the rudiments and ftock, the males and females, with their labouring fervants, that is, the common Bees; and laftly, plenty of food. Therefore it was well provided and prepared to bear fecurely, and, in a regular order, the inclemency of the approaching winter. The order under which the Bees that live in the winter months conduct themfelves is this: they firft open the cells and eat the honey depofited in the loweft part of the hive, afcending by degrees up to the upper parts. This they do in order to preferve a mutual warmth between them; and the female depofits her eggs in the little cells as they are emptied. Therefore about the beginning of March I difcovered the ftock and the Nymph. Let no one be furprifed at this, fince towards the beginning of Auguft I have feen fome thoufand eggs enclofed in the ovary in the female's body; fo that it is natural for the Bees at any time of the year to lay their eggs, and increafe their family. Bees are not therefore confined to the time of fwarming in regard to the bufinefs of generation; indeed, they are always at this work, fince they lofe fome of their fellow-citizens by the injuries of rain and winds, and other inconveniences and diforders; in the place of which they are obliged to fubftitute young ones by a continued generation.

Our keepers of Bees are wont to exprefs by the following proverb, how foon the young Bees are hatched, when they fay, that the firft Swallow and the firft Bee give notice of each other *. There are fome, indeed, who think this fhould be underftood of the flying off of Bees, but this does not feem to be the proper fignification of the proverb.

We muft obferve here, that fome of the cells in the hives are filled with a matter of various colours, which has been gathered and

* Among the wonders in the real œconomy of Bees, nothing more deferves our attention than the certain prefage they have of rain. It has been fuppofed they fee clouds gathering for it, and know where they will fall, but their eyes are not made for fo remote objects It is certain they have fame notice, and that it never deceives them. They haften to the hive and get in before the moft fudden fhowers. One never fees a Bee in the rain, unlefs it be a lame or difabled drone. In all probability they feel the temperature of the air which brings rain; and if we obferve the amazing ftructure of their pulmonary tubes, as defcribed by this author, there will appear no wonder that they feel very fuddenly all changes in the atmofphere.

laid

laid together as it were into ſtrata or beds, like Herrings or other merchandize put with great art into a barrel, which are by degrees and at different times heaped upon one another. This matter I found on examination was granulated, and taſted ſomewhat ſweet. Some of the cells containing it were ſealed up, and others open and only half full: others were ſcarce begun filling, and in others again began to decay. This ſubſtance is called by the Bee-keepers the bread or food of the Bees, wherewith they are ſaid to cure themſelves when they have a flux. But as credulity is often the parent of error, doubting about the truth of that received opinion, I have by various methods ſearched into and examined this ſubſtance: for it ſeemed to be rather the rudiment of wax. I have therefore firſt thrown it into water, in which it was quickly broken and diſperſed, but it always remained in grains: this likewiſe happened when I put it on my tongue. If it be put on a piece of thin glaſs, and placed on a red hot coal covered with aſhes, I have obſerved that by degrees it waſted, grew dry, hardened, and at laſt become black. Nor does it ever melt when thus placed on the fire; nay, if it be thrown naked into the fire, or applied to a burning candle, it never burns. From theſe experiments it ſeemed to me not at all to conſiſt of the matter of fat, for the ſake of examining which I had begun them, eſpecially ſince I obſerved, that it was very like that ſubſtance which the Bees conſtantly carry home, and is fixed on the fifth joint of their hinder legs, and which is taken for wax by all the Bee-keepers. Upon examining this matter which the Bees carry on their legs, I diſcovered that it is abſolutely the medicinal bread of the Bees. Hence it came to paſs, that I could ſcarce perſuade myſelf that the Bees carry the wax perfect out of the fields without any previous preparation; as I cannot be hitherto brought to believe any thing like it of honey, being rather of opinion that this is transformed into a better united and thicker liquid, by digeſtion in the ſtomach of the Bees: though it may, however, be poſſible that in the fruitful and hotter ſummers, the Bees may collect the honey as they find it prepared by nature in flowers into the cavity of their trunk: as the trunk is full of irregular parts, and as it were ſet or planted with glandules; hence it follows that the honey may likewiſe ſuffer ſome change in it. As to the wax I do not doubt but it is prepared by the Bees. However this matter may be, when I afterwards laid theſe doubts before the moſt intelligent Bee-keepers, they were all unanimouſly obliged to allow that no difference could be obſerved between the bread or food of Bees and the wax, which the Bees had carried freſh into their hives *.

I therefore mixed this bread, as it is called, with honey, in order to ſee whether I could gather any thing from thence, but the event of the experiment taught me that I had laid too great ſtreſs on theory. In the beginning, indeed, when it is firſt mixed, it becomes a very clammy and glutinous maſs; and it runs more thin than the honey did before, and becomes ſtill more ſoft when expoſed to the fire: but when it ſuſtains the force of the fire a little longer, it ſoon diſcovers its former nature. It likewiſe breaks in water, nor does it much recede from its former nature or diſpoſition.

From that experiment I am inclined to believe that this is the ſubſtance from which the Bees prepare their wax. But I think they do this buſineſs by the help of their ſaliva or of the execrated and digeſted honey. And hence though what is commonly ſaid may probably be true, that Bees uſe this matter as a medicine; yet I do not doubt but they gather it in the time of plenty, that when ſcarcity comes, or when wet and cloudy weather approaches, or when they cannot from any other cauſe fly out of the hives, they may take their time to perfect it. Any one may know by an eaſy experiment whether this matter be ſo. The Bees therefore ſeem to behave with reſpect to this, in the ſame manner as they uſually do in regard to honey, of which they gather more than they have immediate occaſion for, that they may live thereon in the time of neceſſity. This abundant quantity amounts to ſometimes thirty, forty, fifty, or ſixty pounds. Nay, their zeal and earneſtneſs to gather honey urges them ſo far, that they ſometimes throw their ſtock or young out of the hives and fill the emptied cells with honey: but I ſhould think there is ſome other reaſon for this act, which yet remains to be conſidered and diſcovered.

I think that the Bees probably gather this matter in order to form and perfect it into wax in the times of ſcarcity, to cover up the little cells of the combs therewith, and to faſten it on the webs of the ſpinning Worms. This I ſhall afterwards explain more at large. I am likewiſe inclined to think that this matter ſerves alſo to cloſe up the door or opening of the hive when winter approaches, or at leaſt to make it narrower by way of defence againſt the inclemency of the cold: unleſs one ſhould think it more probable that they ſeparate the matter they uſe for this purpoſe from the reſt of the wax, or gather this peculiar glue from beech and poplar trees; with which, as the Bee-keepers ſay, they afterwards not only make the door or opening narrower, but alſo cover all the lower part of the hive itſelf,

* The French give with great propriety the name Bees-bread, Pain des Abeiles, to the farina or duſty ſubſtance lodged in the antheræ of flowers. It is certain that they eat this, and that it is afterwards converted into wax in their ſtomachs, for they collect vaſt quantities of it when they have no combs to make, and uſe it merely as food.

and plank it, and make a regular margin or border on the infide *. The bread of the Bees appears therefore, in the opinion of the Bee-keepers, to be fomewhat different from the wax; but in my opinion it is the very matter or fubftance of the wax itfelf, not yet prepared. In order to view and inveftigate the ftructure of the Bee-bread, nothing is more proper than to make ufe of a microfcope in the manner following: the Bee-bread is to be put into a glafs full of clear water, and then fhaken a little, in order to feparate it into a fine duft; and when this does not fucceed quick enough, it may be accelerated by breaking it with a fmall fine pencil. This duft is afterwards to be put upon a very thin piece of glafs, as near as poffible to the flame of a lamp; then the glafs is by a little ftarch to be faftened to a fmall piece of cork, which is afterwards to be fixed on the point of a needle and put under the microfcope. Thus it will be found that the Bee-bread confifts only of fine globules of equal form and magnitude; they have commonly three or four corners, but they are often alfo round: this angulated figure may probably be owing to the folidity and compactnefs of thofe little parts, which the Bees bring them into with their teeth: between thefe little parts are found fome yet more minute ones. But though the particles of which that bread confifts are very fine and delicate, yet one may, not the lefs manifeftly, perceive them upon the tongue; for when this Bee-bread is tafted or chewed, it feels like a fine fand in the mouth, or as fugar undiffolved, or divided only into little grains or angular little cryftals. Moreover, when that bread breaks to pieces in water, it never diffolves; but the parts conftantly retain their former figures, and are only feparated and parted from each other. But whether thefe globules, when worked into wax, are ground, chewed or broken with the Bee's two teeth, and mixed with the faliva; or whether they are mixed with the fat or poifonous liquor of the Bee's fting, in order for forming the wax, is a matter which ftill remains to be inveftigated.

It is wonderful that the fat both of men and beafts alfo confifts of fuch minute grains and particles, which when any perfon has a mind to fee them diftinctly, he muft manage and view it in the manner abovementioned. The fat cannot be feparated by water into fmall parts, and therefore in order to break it fufficiently, it muft be fhaken a little in fpirit of wine: for thus it will very eafily divide into minute globules. If it be afterwards put on the glafs and examined in the manner beforementioned, it makes a very agreeable appearance.

This contrivance, wherewith we unite together fuch fine and fmall things, put on glafs that they may be afterwards, when dry, viewed with a microfcope, I here mention for no other reafon but becaufe it anfwers on many occafions: for a great many things which could not be otherwife examined, are by this means very eafily difcovered, as will be made more evident in the following pages.

To return to the Bee-bread, we muft obferve that many fpecies of Mites feek after it; and thofe infects are alfo fond of unmelted fat. This may probably be owing to the many skins the fat is furrounded with; which are confumed in the melting, and which in the natural ftate principally ferve thofe creatures as their food. One may fometimes obferve certain globular particles in that wax, with which the little cells of the Bees are ftopt, and as it were fealed up: and by this new argument the opinion which I have before propofed, that the Bee-bread is really of the fubftance and nature of wax, is confirmed. When wax has been for fome time fteeped in fpirit of wine, it becomes very brittle, and feparates into little particles, which feem alfo to be fomewhat like the broken or divided bread of Bees; but that experiment ought to have been made with virgin wax, which I could not yet do, having been otherwife engaged.

Notwithftanding all thefe things, we fometimes fee that the Bees carry real and perfect wax into the hives. This is compofed likewife of globules; but they are four times, fix times, nay, often ten times larger than the grains of the Bee-bread: thefe globules are likewife of an irregular figure. The Bees, no doubt, fteal this wax, and bite it with their teeth from the wax made by other Bees; and afterwards fix it on their hinder legs in order to carry it into their hives. Therefore thefe little lumps are agreeable to the meafure and magnitude of their bite, or are proportioned to the quantity which the Bees can take off a cake of wax, when foftened by the fummer heat.

But if we attentively confider the experiments that have been hitherto explained concerning the Bee-bread, and at the fame time attend to its granular compofition, it does not feem very probable that the Bees can live on it as their food in winter; for the Bees can take into their bodies only a matter that is not thicker than the honey itfelf, fince they have a very narrow and flender trunk. Therefore, the Bee-keepers always reject granulated honey, or that which is cryftalized or concreted into lumps, as unfit for feeding of Bees, nor do they ever give it to them to eat; but in winter time they fill fplit elder fticks with liquid honey, and draw them through from one fide of the hive to the other. If any

* Befide wax and honey, the Bees collect a certain refinous fubftance, which authors call Propolis. It is of a brownifh red colour, very clammy, and a perfect vegetable refin. They ufe this to ftop up holes or cracks in the hive, and to ftrengthen weak places. It is not of the nature of wax, for it will diffolve in fpirit of wine; and we are not certain from what plants, or parts of plants they get it. The ancients were acquainted with this fubftance, but they fay it was of a difagreeable fmell; with us it is aromatick. Probably the fcent varies according to the plants whence it is obtained.

perfon fhould object that the Bees can bruife or grind this bread with their teeth, and afterwards fwallow it; the anfwer is, that the Bees can do the fame with the granulated honey. My difficulty, therefore, ftill remains unfolved, unlefs any one fhould imagine that the Bees grind or bruife the grains of this bread in their jaws, and then, after mixing them with the faliva, or with frefh honey, by that help, attract and fuck them through their narrow trunk; fince, befides this, they have no other paffage into the body for this purpofe. From thefe reafons I am the more confirmed in this opinion, fince the orifices of the trunk in Bees are fo imperceptible, that they do not feem to me to be larger than the mouth of the meferaic veins, or lacteals, that open into the inteftines, and which will admit only very thin liquids, and fuch as are purified to the higheft degree.

We might further ask how this Bee-bread acquires its roundifh figure? alfo, whether it be dew, or whether the effluvia of flowers and fruits, firft refolved into vapours and afterwards condenfed in this form? or, finally, whether it has its origin from any other concreted fluid, reduced to a globular form by force of the incumbent atmofphere? we have not yet fufficient experiments to determine thefe matters; for, as Bacon juftly obferves, we muft not feign or devife, but find out and difcover what nature produces, and how fhe operates. Something like this prefents itfelf to our view in nature, as may be obferved particularly in gums; between the petals of the flowers of hops, there are alfo feen a great number of fuch granules which are of a bitter tafte.

My honoured father, the fooner to have ripe grapes, brought fome vine branches into a little fhed, built in his garden for that purpofe, making openings in the windows to let them in. I obferved that about thefe branches there was often an infinite number of white pellucid cryftal-like globules, which were fomewhat moift and clammy; nor could I ever melt thofe particles, or refolve them into vapours, becaufe there always remained fome matter from them, which hardened in drying. This I mention particularly, that I may be able to explain with greater accuracy the nature of that peculiar mouldinefs to which the Bee-bread is fubject; for though this mouldinefs appears to be compofed of hairy, or feather-like, or downy little parts, or, as the celebrated Dr. Hooke has delineated in his micrography, of a peculiar kind of minute plants, yet it really confifts of an accumulation of globules that are fome bigger than others. This was firft fhown me at Delphos by the induftrious Leuwenhoek, by the help of a microfcope conftructed after the model of that invented by the honourable Mr. Hudde conful at Amfterdam. And therefore as to this matter, I think that bodies when they contract mouldinefs, emit only effluvia and vapours, which are propelled forward by force of the fermenting and heated matter; and which, being again condenfed by the colder atmofphere, put on a globular figure, becaufe they are on every fide equally furrounded by the incumbent air; and as whilft fome of thefe globules are following others, and continually propel each other higher into, or towards, the air; hence are produced thofe uneven, hairy, and oblong little parts.

The nature of wax fhould have been more accurately inveftigated, in order to difcover whether any fattifh or inflammable matter be orginally mixed therewith out of the body of the Bee, which may be eafily fhewn from the ftructure of the adjacent parts: for the fecretions of the body are very wonderful; here fat, there oil; in one place gall, in another infipid humours; on one fide an aqueous or watry, and on the other, a clammy and glutinous fubftance; in one place volatile falts of an ill tafte, and in another fweet, aromatic, and oily volatile falts. Of this laft fort is civet, wherewith if paper be daubed it bears writing on it; and by this teft we moft certainly difcover whether civet be genuine. But thefe refearches would take up great time and very great labour, for there is not on every occafion a free admittance to all the fecrets of nature; and the incomprehenfible weaknefs of our ftrength is confined in every ftep within its ftated limits and narrow bounds.

I pafs now to the comb, or the cells and tubes of the Bees, which they form and conftruct with wax, then fill with honey, and again clofe up with wax; hence the comb properly fignifies wax formed into cells and filled with honey. I fhall firft treat of the cells of the working Bees, then of thofe of the males, and laftly, thofe of the females. All the cells of the working Bees are hexagonal both above and below, but the angles of the upper part are equal among themfelves; that is, they are equally wide, whereas in the lower part the angles are unequal; for three of them, in that part, are funk deeper than than the other three; the reafon of which is, becaufe every cell, if it be a regular edifice, is built on the foundations of three other cells. Since therefore the foundation of the Bees cells tend obliquely downwards, like a triangle, therefore two angles make only one defcending oblique angle: and confequently the internal bafe of the cells conftantly tends obliquely downwards, and is divided into three diftinct parts, each of which anfwers to the two fides of the hexagonal circumference of the cell. The three angles juft mentioned are commonly right angles; and when they are pierced with a needle, that is, if every angle of the foundation be perforated, fo that each cell is pervious by three apertures or holes, then thofe three apertures penetrate on the other part into three diftinct cells. It appears moft evident from this palpable argument, that a cell

cell is founded always upon three other cells, and therefore has a common divifion with them; for none of the cells is circumfcribed by any limits or partitions peculiar to it alone, fince all things are common between the Bees as between brothers. If the edifice be irregular it fometimes happens that one angle of a cell refts, or is fupported on a fourth cell: this does not happen frequently, though I have lately obferved it in a work that was pretty regularly built.

The foundation of the cells is placed in the middle, and the cells on every fide reft on this foundation, which is commonly like a wall, perpendicularly extended from the upper towards the lower parts; and then on each fide againft this kind of wall are placed cells lying obliquely on their fides. Suppofe fome empty ale or beer glaffes to be piled upon each other againft the fide of a thin wall, and you will in fome meafure underftand the difpofition of thefe little cells: fix, eight, or more fuch walls, furnifhed with cells, are fometimes found in one hive, and they are always placed at fuch a diftance from each other, as to afford the Bees an eafy paffage between them. But, left thefe combs fhould fall down when they are full of honey, the Bee-keepers fix little fticks in the hives when they are empty, about which the Bees form their works of wax.

All thefe cells, as well as their foundation, are formed of a continuous, but not contiguous, matter, fo that all things are continued, nor can the cells be feparated from each other by any artifice, but by breaking or cutting them, whatever fome might have erroneoufly imagined, thinking that every Bee built its own refpective cell. Of this matter we fhall treat hereafter more at large in its proper place.

If the whole edifice be regular, then five of thefe little cells make exactly an inch, and fifty-five an Holland foot. Hence a French gentleman obferving this, and imagining that thefe cells were conftantly built after the fame rule, thought he had difcovered an everlafting meafure, which as it could never be deftroyed might be introduced among all nations. This invention would be certainly confirmed, and its importance proved, if thefe little cells were always fo exactly conftructed, and the combs in all nations were conftantly of the fame magnitude; but with us the combs are not always fo exactly regular as is commonly believed, though if we view the cells only curforily, they do not feem to differ a hairs breadth in meafure from each other. If any one compares them accurately one with another, he will fometimes find them irregular; efpecially when they are made by the Bees in fuch a manner, as to fit them only for receiving the honey. The three parts of the foundation of the cells that tend obliquely downwards are ufually fquare, but they are fometimes oblong, and fometimes of a rhomboidal figure; nay, I have obferved that fome of them were longer or fhorter than others, and were alfo fometimes narrower and fometimes broader. Nor does every little cell reft conftantly on three cells, but fometimes on two and an half, and fometimes on three, and a part of the fourth. Moreover, thefe entire cells are fometimes twice or thrice as long as ufual, and they are likewife fometimes crooked or finuated, altogether like the cells of Hornets, which are commonly fomewhat crooked, becaufe they are extended little beyond their foundation or center. Bees never build in this manner, unlefs when very great plenty of honey offers to be gathered, for then I have feen cells full of honey, fealed up and fufpended like large lumps of earth in the hive.

In regard to the cells of the female Bees, erroneoufly called the kings, and the parts where they are joined to others, confiderable irregularities frequently occur; though all of them viewed curforily may feem alfo to be very regular.

We muft further obferve, that the Bees never build their cells feparately, that is, fo as to perfect one before they begin another; they always enter upon building a great number of cells together with their foundation at one and the fame time. In the beginning of the work, they lay that hollow triangular foundation which bends down obliquely, and terminates or gathers itfelf in acutely; then they conftruct the lower and hexagonal or unequal fides: fo that in one and the fame hive, may be feen at the fame time, the beginning of the foundation, and the rudiments of the hexagonal divifions of the cell on one fide, and the fame cell on the other fide, raifed higher on the fame foundation, and other fides again but juft begun and rifing. Moreover, in regard to this building of the cells, a very wonderful and artificial direction or management of the Bees is to be mentioned. This they put in practice when the rifing hexagonal fides of the cells are very thin and weak; and when they have a mind to leave fuch cells imperfect for fome time, which is the cafe when the female, in order to lay her eggs, goes to another part of the hive; as I fhall explain more at large hereafter. When this happens, the Bees firft fortify all the edges or borders of the hexagonal and imperfect fides, left they fhould be broke or bent in the mean time, which might eafily happen by the frequent running of the Bees over them. They therefore furnifh the fides of the imperfect cells with a margin or border glued thereon in the upper part, and prepared of a thicker and more folid fort of wax, and they put this waxen border on the extreme circumference of the hexagonal fides, fo that, by this means, the hexagonal figure of the cells, which was beginning regularly to fhew itfelf, is again in a manner obfcured. They fometimes alfo border the cells that are finifhed and perfected; from which this further good arifes, that when fuch cell is to be afterwards clofed up, there is no neceffity for fo much time or

wax.

wax. The Bees, therefore, ufe the fame precaution in refpect to their imperfect cells, as if any perfon fhould cover the extreme edges or borders of the tender and broken fides of a glafs cup with fealing wax, in order to ftrengthen it and handle it with lefs danger.

The cells of the males are one third lefs than thofe of the common Bees, but they are made in the fame manner; and they are commonly placed in the loweft part of the comb; for they are built after all the other cells are finifhed; fometimes there are three hundred, four hundred, or even more of thefe in one hive, but often fewer. The Bee-keepers attribute the fmaller number of thefe cells to the drynefs of the year, and the greater number to plenty of rain in the air: hence they fay that a great number of males in a hive is a fign of a very wet year. But thefe are mere fancies, arifing from a notion, that the Bees, when the feafons are dry, are intent only on gathering honey; and, on the contrary, in wet feafons, mind principally generation, but though thofe perfons have kept Bees fifty years, they underftand nothing of the bufinefs of their generation, nor do they know what fort of a creature the breeding Bee is, for they call it the male. I would not have it underftood here, that the number of the cells which I exhibit is abfolute and exact, for I have made the calculation in general from their numbers; nor have I even, very accurately, counted them all.

There are fometimes thirty female cells found in one hive few are perfect, but a great many unfinifhed; their ftructure is not regular, but they are for the moft part oblong, and roundifh, and fomewhat pear-fhaped: fometimes they are confiderably ftraighter, and have a lefs fwelling than a pear, but others again are fomewhat more globular. Their external furface is unequal, rough, and marked or diftinguifhed by little holes and exuberant prominences, and is conformed only to the figure of the comb. The infide of the cells of the common Bees has a very fmooth and polifhed furface; but thefe differ again from them in that they form a cavity like that of a bottle or a fcooped pear; from this fhape, they are very capacious, and furpafs in bignefs the cells of the common, and thofe of the male Bees. The females therefore have a much larger fpace than the other Bees to turn themfelves more freely in their cells; the reafon of this difference I fhall explain in its proper place. The cells of thefe females are ufually, nay, almoft always fituated near the borders and prominent extremities and edges of the hive, and are feldom found placed in the center or in the middle between the other cells; all thefe particularities tend to certain ufeful ends, and therefore the laws of making them were not impreffed on thefe little creatures without defign, by the moft wife Creator. I fhall now endeavour to illuftrate with figures what I have hitherto related. The firft figure, Tab. XXIII. exhibits a regular hive of common Bees, as it prefents its hexagonal and regular fections to the eye, when viewed in the upper fide; nor could it be poffible to delineate thefe fections, without the affiftance of fome new-invented lines; which being allowed, it is then eafy to defcribe the fections, for which reafon I here delineate fome of thefe lines. The fecond figure under the letter *a* exhibits three fingle cells of the common Bees, broken from the reft of the comb, with their triangular bafis running down obliquely. The letter *b* reprefents one cell only, entirely feparated from all the reft; in this, befides the obliquely defcending triangular foundation *c*, are likewife feen under the letters *d d* two unequal or uneven parts or productions of the hexagonal fides. Now if you fuppofe this cell *b* placed on the cells *a*; it will follow that its three oblique angles agree with the three angles of thefe cells, and are fupported by them. The third figure fhews a little cell cut through the middle, in which may be feen the triangular foundation and the fix fides; one of them is formed out of the oblique angles, as appears at the letters *b b*. Moreover, fig. IV. fhews fifteen little cells, cut on each fide, between which a part of the triangular foundation, which runs obliquely, is plainly feen in each cell. It is here alfo evident in what manner thefe cells *a b* are built upon the fame foundation *d* whereon the cells of the other fide reft *c*. Again, the letter *d* very exactly reprefents the the triangular foundation, which runs in obliquely, as it really is feen in nature. The fame is likewife delineated under the letter *g* between the cells of each fide, but it is here divided by a fection which paffes through the two angles. The letters *f f f f* exhibit two long fides of the cells; but the letters *e e e e* the two fhorter fides. For every cell, as I have obferved before, has in its lower part three longer and three fhorter diverging fides, which in the upper part are of an equal length.

The fifth figure which follows next, reprefents fome cells of the males, which are a third part larger than thofe of the common Bees. In order to render this difference the more confpicuous, I have delineated them fomewhat larger than they really are. Between each of thefe cells is feen that triangular obliquely diverging bafis, each of whofe angles agrees with the defcending fides of the cell. But I have not delineated the cells that are built on one fide of this bafis, becaufe it did not feem neceffary. To the upper part of thefe cells is obferved to adhere a pear-fhaped lodgement of the nature of a cell: this is defigned for the females. It is irregular in the upper part, and is adorned as it were with depreffions or little holes, here and there impreffed on the wax.

If the cells hitherto defcribed have been lately finifhed, and have not yet any honey, or Bee-bread, or eggs, or Worms, or riper iffue in them, in that cafe their fubftance is genuine virgin wax, which has no foulnefs among it,

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and may be all melted. On the contrary, the wax that is whitened by bleaching, and which is fold in the fhops by the title of virgin wax, has nothing but the name, fince it lofes a great part of its ftrength by being adulterated with powdered talc, and bleached in the fun.

The honey likewife which is collected pure in thefe virgin cells, and flows again out of them fpontaneoufly and without preffure, is pure virgin honey, better and more perfect than any other honey whatfoever.

It is feldom obferved, as the Bee-keepers fay, that the cell of a female is joined to the cells of the males: but experience has taught me the contrary of this, having in my poffeffion at this time a fpecimen, in which the cell of a female is built adjoining to thofe of the males. As many others, fo this error had its origin from that imagined regal dignity, which they have wrongly afcribed to the female; for from this the notion was eftablifhed, that the favour of coming fo near to the king was too great to be granted to the drone. But the accefs of the drone to the queen is fo neceffary, that fhe cannot be impregnated unlefs fhe be firft familiar with, and affifted by the fpermatic virtue of the drone, who is the true and only male.

All the families of the tripple kind of Bees would therefore perifh, unlefs there were this intercourfe: fince what is erroneoufly called the drone is the real male Bee, and therefore does not claim to himfelf a lower place in the hive than the queen herfelf the female parent. To this may be added, that the drone is more tractable and mild in its conduct and difpofition than the two other kinds of Bees, for it employs its whole time in the labour of love and procefs of generation; nor is it armed with a fting as the others, nor to be dreaded for its mifchievous qualities.

To conclude, how do the Bees make thefe cells? and by what art do they build them in fo ftupendous a manner, fo regularly, that they cannot be fimply or plainly delineated but with great labour, and by the intervention of fome new fpecies of lines, and not even then without committing great errors? He furely who fees all things, and promotes the generation of the wild herds; He, and He only knows this. I fhould think this matter may be probably inveftigated and brought to light, if any one would labour at it with the needful diligence and attention: nay, I am confident, that I myfelf could fucceed in the inquiry, if I had an opportunity of feeding the Bees for fix months, and enjoying the peaceful bleffing of a country life. However this matter may be, I confefs myfelf now as ignorant thereof as all others. However, I firmly believe, that the Bees make ufe chiefly of their teeth for this bufinefs: hence the common Bees which alone build all the cells of the hive, have much larger teeth than either the females or the males; nay, the males have ftill fmaller teeth than the females, and probably the males have them for no other purpofes, but to bite open their little cells when they are come to full maturity therein, or to open thofe filled with honey when they want to eat. Whether the legs of the Bees, between the claws of which a fingular kind of foft matter is produced in knobs, contribute in any meafure to perfect and elaborate the wax, I am likewife hitherto at a lofs to difcover. Yet I fcarce doubt, but that humour which paffes through the fting of the Bees alfo conduces fomewhat to prepare the wax, and fit it for building the cells. It would be worth while to examine all thefe points more accurately. It is very wonderful to fee how inftantaneoufly the Bees, when they are offended, emit all their poifon through their fting. This poifon may be feen at the end of the fting, and is like a little drop of cryftal. But if this little drop, while ftill adhering to the extremity of the fting, be fuffered to grow dry, it then remains pellucid and concretes, and is like the boiled cryftaline lens of a fifh's eye; it is therefore very eafily condenfed by the circumambient air.

Since I am treating of the wonderful induftry of this little creature, which, however, is not more remarkable than that which all other infects fhew, according to their refpective difpofitions, I cannot help here mentioning, to the glory of the great Architect and Artift, the wonderful works of a certain infect, the external form of which has been very clearly defcribed by Goedaert in the firft part of his Nat. Metamor. Exper. x. This infect is the nocturnal Butterfly or Moth, which glues its eggs fo ftrongly and firmly in the form of a circle to the branches of trees, that they make an impreffion upon the bark, and often prevent the increafe of the branches. What occurs here very extraordinary is, that the eggs of this infect are formed in the fame manner as thofe hewn ftones, which are adapted to build the arches and roofs of houfes, and have one fide narrow and the other broad, that they may be the more exactly joined together, and conftitute one firm arched form. They may likewife be compared to the lines of a circle drawn from the center to the circumference, which are the nearer to each other the more they approach to the center, and diverge towards the circumference. In this manner has the fupreme Architect, the Almighty, formed thefe eggs, which are artificially and in a fpiral curvature fo ftrongly glued together, and affixed to the tender branches of trees, by this infect, who for that purpofe walks many times about the branches, that they cannot be loofened by rain, or any other liquid that I have yet applied. Out of thefe eggs, which, according to the accuftomed order of nature, by which the egg of the Butterfly is only a Worm inclofed in its fhell or cafe, fhould have produced Worms or Catterpillars, I have feen Flies wonderfully fmall, immediately iffuing in their perfect ftate. This obfervation feems to me to be the moft extraordinary of all in this part of natural

ral hiftory; and therefore, I hope I fhall, with the affiftance of God, at fome time write a particular treatife thereon. I have here given the hiftory of this ring of eggs, becaufe it will be hereafter made ufe of in its proper place, and produced for the fake of illuftration.

I fhould never conclude this part of the work, if I attempted to exhibit the defcription, induftry and art of thefe creatures, or to give but a rude delineation thereof. I cannot help mentioning here, the fingular skill and addrefs, not indeed of an infect, but of a fanguiferous animal, that is, of a young houfe Dog which I keep. This creature is afflicted with a running ulcer or fiftula, which is fituated fo high at the lower part of the eye, that his tongue cannot reach thither to lick it. Therefore this creature follows a remedy happily invented and difcovered, as it were, by reafon, and applies it to this evil; it firft wets its foot with its fpittle, and then rubs the moifture with wonderful dexterity over the ulcer, endeavouring to cure it in this manner: nay, when the mouth or orifice of the fiftula has at any time clofed, the creature rubs it fo long with its foot, that the furface becomes very red like blood.

To return to the Bees. They are about the beginning of Auguft inflamed with fo much hatred againft the males, that they unmercifully and for no crime kill them: whereas, at the end of May, and fometimes fooner, they build houfes for them, carefully nourifh them, bring them there, and take all poffible care of them. I fhall afterwards endeavour to explain, in its proper place, the reafon of their changing this love into hatred; fince I have refolved to compofe this hiftory to the glory of God alone, without any other view.

Before I proceed further in this refearch, I fhall defcribe the male, female, and common Bees together, and compare them one with another as to their external parts, beginning with the common Bees, which are moft eafy and familiar to be known, and which have been at one time or other feen and handled by every perfon. In the common Bees as well as, in all the other kinds, we are principally to obferve the twelve divifions or rings of their body; five of them are placed about the head and thorax, and that flender and delicate part which connects the belly with the thorax, and the other feven in the body.

The head of the common Bee is oblong, fomewhat rounded above and fharp below. The head of the male is throughout of a rounded form, and that of the female Bee is oblong.

The eyes in the head of the common Bees are of an oval or lunated figure. They are of the fame form in the males alfo, but they are two thirds larger than thofe of the common Bees: this deferves to be well regarded. There is fomething like this in the Ephemerus or Day-Fly; the eyes of the female Bees are fomewhat larger alfo than thofe of the common Bees. The eyes of thefe three fpecies of Bees are covered or furrounded with briftly hairs, and are feparated from each other by a number of the like hairs. Thefe hairs are twice, nay thrice as long as the diameter of the little fpheres into which the eyes are divided. The fame thing is likewife obferved in other infects. In the upper part of the head fomewhat higher than where the hairs juft now mentioned are fituated, we likewife difcover many fmall feather-like hairs in the common Bees, and nearly in the fame part alfo, three peculiar little eyes. Thefe feather-like hairs are not found in the males, for their eyes are extended fo far in that part that they touch each other. And this is alfo the reafon, that three of their eyes in particular are fituated much lower than they are in the common Bees, and juft above the horns. The female agrees with the common or working Bees in thefe particulars, that her eyes are feparated in the fame manner from each other, and there are three peculiar little eyes likewife placed in her head in the fame manner.

All Bees have two horns or antennæ. Thofe in the working Bees have only five joints, but thofe of the males have eleven, and thofe of the females the fame number. The firft joint, where the horns rife from the head, is oblong in the common Bees, but in the males it is fomewhat fhorter, and it is again fomewhat longer in the females. In the common Bees there is a fmall quantity of fhort hair, under the horns, but the hair under the horns of the males is more in quantity, longer and feathery; in the females again it is obferved to be like that of the common Bees.

Above the teeth in the common Bees is feen a remarkable kind of horny or bony lip, which is not fo obvious in the males; but it is found in the females in the fame manner as it is in the working Bees.

The common Bees have two long teeth, the males have very fhort and fmall ones; thofe of the females are fomewhat larger than thofe of the male Bees, fo that they hold as it were the middle place.

The probofcis is very long in the common Bees; in the males it is fhorter by one half. I have hitherto miffed the opportunities of examining it in the females.

The thorax is roundifh in all the kinds of Bees, and in the upper fide of the hinder part it is provided with a fomewhat prominent border or margin. In the common Bees this thorax is covered with thin feather-like hairs: in the males thefe hairs are more clofe fet together, and thicker, but not quite as long; they are alfo of a more gray colour than in the common Bees and females. The females have a lefs number of thefe hairs than either.

All the kinds of Bees have four wings. Thefe are longer and broader in the male than in the common Bees; but in the females, though the wings be longer, and probably longer than even thofe of the common Bees, yet they feem fhorter, becaufe the lower part of the female's body is vaftly larger and longer than

than either of the others, in order to give room for the eggs.

Each of the three kinds of Bees makes a noiſe by the motion of its wings, which is increaſed by the internal air propelled out of their bodies through the air tubes at the ſame time; for ſome of theſe pipes open with wide apertures under the wings. Certain cavities alſo, fit for receiving and vibrating the air, and formed under and between the wings, contribute to this. Nor muſt the ſhoulder-blades be excluded from their ſhare in this muſick, they being placed juſt above the wings, joined to the thorax, and having under their breadth the gaping orifices of ſeveral air-pipes. It is thus the motion of the wings, with the aſſiſtance of all theſe parts, and by the force of the propelled air, make the humming noiſe peculiar to that inſect.

All Bees are provided with ſix legs, each of which conſiſts of nine joints; the thigh has three of theſe, the leg two, and the feet four. In the common Bees the hinder legs are broader than the fore ones; but this difference is not ſo remarkable in the males or females. On the fifth and broadeſt joint of the hinder legs, which is the firſt joint beyond the thigh, the common Bees on each ſide carry wax, or the Bee-bread, collecting it into a heap at the outmoſt ſide of the leg, for there the leg is not ſo hairy as on the inner ſide. In that part alſo the lower, and near the next joint of the leg, are placed ſome briſtly and almoſt horny hairs which are neither found in the males, nor are ſo diſtinctly viſible in the females. The third or laſt joint of the leg is longer than the two former, but the two next joints are ſmooth and ſomewhat broad, and thoſe are cloſely covered on the inſide with fine feather-like hairs. The leaſt of the four joints of the legs is alſo ſomewhat broader than the three former; and in this part are inſerted ſtrong muſcles, deſigned for moving the claws of the feet.

The feet are armed with two larger and two ſomewhat ſmaller claws; but the ſmaller are as it were jointed or articulated into the larger.

Between the claws of every foot is ſeen a very ſoft matter, of a membranous texture, from which, when wounded, there flows a clear liquor. The Bees in walking can at pleaſure turn out this tender part of the foot, and therefore I ſhould think, that having drawn back the claws of their feet, like Cats when they are playing, they are able in this manner to run over their young brood, or over the new formed wax, without doing the leaſt hurt to either.

The four hinder legs are placed at the lower and hinder part of the thorax, the two others are fixed to the fore part. And this is the reaſon why theſe two fore legs, when you take the head of the Bees from the body, are ſeparated together with that, and remain with it, being fixed to it as it were by a kind of ligament.

In the common Bees the ſeven laſt rings of the abdomen are of a blackiſh brown: in the males they are yellowiſh, as they are likewiſe in the females, but more eſpecially about the lower part, for there the rings of the abdomen are almoſt all yellow; and this is the reaſon the queen Bee is ſaid to be of a golden colour.

The ſting, which in the common Bee is protended ſtraight from the body, is wholly wanting in the males, and in the females it is bent *.

The common Bee is little more than of half the bigneſs of the male, the female is alſo ſmaller than the male or drone, but it has a much ſlenderer and longer body, in which, as well as in bulk, it conſiderably exceeds the common or working Bees.

The colour of the common Bee approaches to an obſcure yellow; the males are ſomewhat grayer, and the body of the females is more of a gold colour.

The parts of the Bees hitherto mentioned are almoſt all hairy or ſhaggy, and when they are viewed with a microſcope, we obſerve that thoſe hairs are in reality very beautiful feathers, as is ſhewn in Tab. XVII. fig. VIII. This ſhall be explained afterwards more at large.

The common Bees may be conſidered as natural eunuchs as it were, belonging to neither ſex; though, however, with reſpect to their ſtructure and diſpoſition, they approach nearer to the female than to the male ſex. The males have very conſpicuous and large genital organs. The females have an ovary, and in it an infinite number of eggs, as I ſhall deſcribe in its place. But the common Bees are not furniſhed with either maſculine or feminine genital parts.

As to the internal parts of the Bees, the three ſpecies have ſome common to each of them, and others peculiar to each. The internal parts common to all, are in the head, the brain conſiſting of the cerebrum and cerebellum; the beginning and globular dilations of the ſpinal marrow, which thence pervades the whole body from one extreme to the other; and laſtly, the nerves iſſuing as well out of the ſubſtance of the marrow, as from its dilated little knots; all which I have deſcribed and delineated in the diſſection of the male Bee. The internal ſtructure of the eye is alſo in general the ſame in the three kinds; the tunica uvea, the inverted pear-ſhaped fibres, and the cortical ſubſtance which performs the office of an optic nerve, are very little different in

* The beſt way of viewing the ſting of the Bee by the microſcope, is to hold the creature faſt by the thorax with a pair of knippers, and it will thus thruſt out the ſting, often, in its fury. This ſhould be cut off with a fine pair of ſciſſors, and it may thus be preſerved entire between two ſlips of iſinglaſs.

Another way is, to make the Bee ſting a thick leather glove. This will be eaſily obtained, by catching one with ſuch a glove upon the hand. The Bee will ſtrike with its ſting, and it muſt be immediately frighted off. By this means it leaves its ſting in the glove, which may be picked out and viewed.

either. This I have likewiſe exhibited in the figures of the male Bee. In reſpect to the muſcles and nerves of the proboſcis and jaws there is no difference. In the thorax each of the three kinds ſhews the muſcles of the wings and legs, as alſo many pulmonary tubes and ſome fat; ſome of this is likewiſe found in the head. In the body is ſeen the continuation of the gullet, which deſcends thither from the mouth through the thorax: we may likewiſe perceive there the ſtomach, the ſmall and great guts, and ſome valves; we diſtinguiſh alſo ſix peculiar glands, placed between the inteſtines, as I have deſcribed in figures in the common Bee. The lungs are alſo very particularly ſeen in the body, as are alſo their dilated bladders and branching pulmonary tubes; all which I have likewiſe delineated in the common Bee. The heart, together with its dilations and the pulmonary tubes which run all over its ſurface, is in great part alſo placed in the abdomen, though it may in part likewiſe be ſeen in the breaſt and neck, as I have delineated in the female. In fine, a great quantity of fat is alſo found there, and we perceive ſome membranes and muſcular fibres ſituated under the rings of the abdomen, and deſigned for moving thoſe parts; as alſo ſome ſmall pulmonary tubes which paſs through thoſe parts. I have repreſented all theſe in the female Bee, and they are common alſo to all the three kinds.

The internal parts peculiar to each kind, are, firſt, the genital organs of the male; that is, the internal horny little bone belonging to thoſe parts, the penis, the teſticles, the vaſa deferentia, and their dilatations, the ſeminal veſicles, a peculiar ſmall part that is cut into five diviſions a pear-ſhaped little part, and two appendages which terminate in a point. In the female are likewiſe ſeen the parts that ſerve for generation; the ovary, the oviducts with their diviſions, the eggs, the pulmonary tubes appropriated to them, the two trunks of the womb, through which the eggs are conveyed, the neck of the womb, and the bag containing a glutinous matter.

The following parts are peculiar in the common Bee; the ſting and its poiſonous bag, with its tubes iſſuing as well out of the fore as hinder part thereof; the caſe of the ſting, and alſo its ſupports, cartilages and muſcles, none of which parts are found in the male.

By this general and particular compariſon of the three kinds of Bees with each other, it is ſeen that the common working Bees approach nearer to the nature and diſpoſition of the females than of the males; ſince the external and internal parts in general, as will be made plain hereafter, agree in both: excepting only that the common Bees have no ovary, and therefore, like women who have lived virgins till they are paſt child-bearing, ſerve only the purpoſe of labour in the oeconomy of the whole body. Theſe are thus by nature rendered incapable of doing any other buſineſs but that of nouriſhing and educating the young offſpring, building the little cells for the Worms of the females progeny, and providing food for themſelves and theſe their brethren, that they may have wherewithal to live in the winter ſeaſon, and at all times in rainy and ſtormy weather. The female, on the contrary, and the males do nothing of all this; for the female lives in the hive for no other purpoſe, but to depoſit, as occaſion offers, her eggs in the cells: and it is the buſineſs of the males to impregnate thoſe eggs before they are caſt out, whilſt they ſtill lie in the ovary of the female: this they do during one whole year, that is in the time between the two ſwarms.

For theſe reaſons the common labouring Bees maintain the males and females with plenty of honey. But as ſoon as this ſeaſon of generation is over, and the males having performed their duty, the labouring Bees kill them as being entirely uſeleſs and unable to do any more good, though they might have lived longer. I could wiſh indeed that I had an opportunity of inveſtigating this matter more exactly, and trying whether or not I could keep a whole hive, containing only males and one female for an entire year. This is indeed much to be doubted, for experience ſhews that many Bees die ſpontaneouſly, and without any violence, about the time of this univerſal ſlaughter. Sometimes when the female is unfruitful, or of a bad conſtitution, or when there is too ſmall a number of Bees, or there are two females in the hive, the Bee-keepers ſay that the males are ſometimes found to live till the winter is far advanced: but they never continue to the beginning of ſpring; which, whether it is to be attributed to the natural ſhortneſs of their life, or whether they are then deſtroyed by the other Bees, is not hitherto ſufficiently known.

From one female, which is the only one of that ſex in the whole hive, are produced all the three kinds of Bees, in nearly the following proportion, ten, twelve or fourteen females, ſome thouſands of the labouring Bees, and laſtly ſome hundred males: more or fewer are occaſionally found in the hives of each kind. I have deſcribed another ſpecies of inſects in my general hiſtory of the inſect tribe: the males of which is winged, but the female has no wings; which is alſo a wonderful kind of wedlock. The omnipotent God has been pleaſed to join ſeveral males to one female in this family of the Bees; whereas on the contrary among domeſtick fowls, and in many other inſtances, one male is ſufficient for a great many females. This is likewiſe the caſe in many of the inſect kind; that is, that one male ſhould impregnate many females. This is obſerved with reſpect to the males of Silk-worms. But the female among the Bees is impregnated in a peculiar manner, merely by odoriferous effluvia.

Six days after the time of ſwarming, the young female Bee newly got out of her cell,

 depoſites

depofites her eggs in the new-built cells of the combs: the labouring Bees which attend the female during the fwarming, begin immediately at the very time when the hive is prefented to them, or as foon as they have chofen a convenient place for themfelves for, they have no guide or director, to make their combs; and the female doing her office as haftily, the frefh combs are in a very fhort time filled with her eggs: the female drops one egg into each cell; and what deferves great attention is, the female is fo expeditious in this work, that fhe does not regard whether the cells be only juft begun or perfected, or whether they have been built fome time. It is enough for her the obliquely deverging triangular foundation be laid; there fhe immediately drops in her eggs, and the labouring Bees, which, for this purpofe continually attend the female at that time wherever fhe goes, afterwards further perfect the unfinifhed cells. To execute this work, they are ftimulated with an extraordinary folicitude, love and induftry, impreffed on them by the fupreme Creator towards thofe tender eggs, which are to afford the offspring of the Bees, as towards their natural brethren. We muft particularly obferve, that the earneftnefs wherewith they undertake the care of bringing them up, is not extinguifhed in them; though the female be taken from among them, as I fhall explain in another place, where I fhall alfo demonftrate that the whole fociety of Bees regard not any thing elfe but only propagation and rearing of their young; nor is there any other government whatfoever, nor any election, or any politic or œconomical difcipline or order among them. The moft wife, and all and every where adorable God, has implanted fuch ingenuity and wifdom in thefe infects, that they can bring up their iffue and prepare habitations for them, which the fame moft powerful Creator has not been pleafed to give to other creatures; whereof, among the reft, the Silkworms may be an inftance; and it may be evidently proved that the cohabitation of Bees has no other end but to perpetuate their fpecies; and thus, by the help of an exact order of production, to perpetuate their continuance.

From thefe confiderations it therefore follows, that among Bees there is no wifer regulation than among domeftic fowls; for they have their natural defire to fit; they make nefts, and nourifh their young, being compelled thereto by fuch laws as they cannot avoid nor fupprefs by any rational principle; becaufe they are impreffed on them by the eternal law of natures. Thefe little infects are under as great neceffity to perform all thefe actions, as the winter is to follow the fummer. The only difference among the feveral kinds is, that fome execute thefe functions in a manner more convenient, more orderly, and more agreeable to reafon than others. This appears chiefly in the Bees, and hence there is no authority for the prevalent and common opinion that the government of Bees is carried on with the fcepter of prudence and judgment, under law, and with rewards and punifhments: for in truth all that order which we fo much, and not without reafon admire, is impelled by nature, and is only defigned for the propagation of their fpecies. But we muft not for this reafon deny, that the Bees in performing their work, difcover and exert the appearances of wifdom and the moft prudent counfel; for the facred writings teach us, that God has deprived thofe creatures of reafon, to whom he has not thought proper to commit the care of nourifhing their young. This office is not granted to the Bees only, but is given to the Hornets, Wafps, to humble Bees, and to Ants; which, as well as all other infects, would doubtlefs have perifhed as foon as they had laid their eggs, unlefs they had the care of educating their ftock committed to them: for which reafon it is neceffary they fhould live fomewhat longer.

Behold! God fhews himfelf fo ftupendous in thefe fmall creatures, that I fhould almoft prefume to affirm that the ineffable miracles of God are fealed up as it were in the hiftory of thefe infects. But thefe feals are at length opened, when we diligently perufe and often read over the book of nature, and natural theology, wherein the invifible things of God are explained to the eyes; then treafures of miracles which no tongue can worthily defcribe prefent themfelves, and the unfeen Creator becomes fo manifeft in thefe his fmalleft creatures, that the experiments I have made on them are to me the ftrongeft and moft irrefragable arguments, by which I conftantly maintain his eternal Godhead and providence againft all oppofition. Atheifts allow only a fictitious putrefaction, and a metamorphofis, invefted in their own brain, and the fortuitous conflux of atoms; by the help of which they affert, indeed with very weak and forry arguments, that thefe creatures are produced; whereas, on the contrary, the limbs and parts of thefe minute creatures are conftructed with greater art than thofe of the largeft animals. The Loufe or Mite itfelf proves a deity, and the majefty of God is as ftupendous and worthy of admiration in the minutenefs and fmallnefs of that creature, as in the unwieldy ftrong Leviathan: thofe who view him in thefe his works cannot but reverence and adore him. God himfelf fpeaks to man in this glorious manner in the magnificence of his works. And in what other thing can he be known but in his creatures only? Having named the Loufe, I fhall here add that the little part of that creature which is fo elegantly moved up and down in the body, is only the ftomach and the inteftines annexed thereto, which produce fuch an effect by the force of their periftaltic motion.

The eggs which are laid by the female Bee in every little cell of the comb, are oblong, fomewhat bent, and thicker on one fide than

than on the other; but they are throughout tranſparent, limpid, and bright, and are full it ſeems with a watery matter, and faſtened by a very ſmall extremity to the wax. On the other extremity, therefore, the egg ſtands upright in its cell, and it touches not the wax except at one end. After what manner theſe eggs are ſo firmly faſtened to the wax, I ſhall explain in its proper place. We muſt only obſerve here, that almoſt all ſpecies of inſects, when they are about to bring forth young, affix their eggs by ſome means in that firm manner; whereof I can indeed exhibit many very uncommon inſtances. Among others, I have eggs of inſects diſpoſed in a ring, which are thus glued round the branches of trees; I have ſome other eggs hidden as it were in froth: others again which are covered very thick with hair, and ſo on without end. As to thoſe eggs that are covered or beſet with hairs, we muſt obſerve that Butterflies, which ſtrengthen their eggs with ſuch an integument, have thoſe hairs originally ſituated in the circumference of the hinder part of their body: and therefore when they bring forth or lay an egg, ſome of thoſe hairs naturally ſtick to it, becauſe it is covered over with a viſcous moiſture; and thus all the eggs become at length ſhaggy: the creatures themſelves become bald by this in the part juſt mentiond, which is a very remarkable obſervation. Thus we may learn ſomething worthy of attention from every part of God's works: for that Almighty power goes through all lands and tracts of the ſea as well as the higheſt heavens.

When the eggs of the Bee have been hatched in the comb, then in the bottom of the waxen cell there is obſerved a kind of web of a membranaceous texture, to which the egg afterwards adheres, or is firmly faſtened.

But the egg is not always fixed in the ſame place, that is, in the bottom of the cell; ſometimes it adheres ſomewhat higher and again ſomewhat deeper, according as the obliquely diverging cavity of the cell itſelf is variouſly conſtituted, or according as the hinder part of the female's body, can be moſt eaſily thruſt into this cavity. However, the eggs are conſtantly placed on the obliquely deverging foundation of the cell, though they do not always ſtand perpendicularly upon it; but ſome more, ſome leſs obliquely: for the foundation always deſcends perpendicularly, though the angles are ſomewhat inflected.

If the egg of the Bee be viewed with a microſcope, it appears ſomewhat wrinkled: but thoſe wrinkles are regular, and are laid almoſt in the ſame order, as in the skin of Fiſh after the ſcales are off; which, the veſtiges of the ſcales being ſtill conſpicuous, are yet diſtinguiſhed in a regular manner. Something like this is alſo obſerved in the skin of Birds ſtript of their feathers.

I ſhould think that the hinder part of the encloſed Worm lies in the thicker extremity of the egg, and the fore part in the thiner extreme. This Worm in ſome days afterwards breaks open the membrane of the egg, and creeps out of it under the form of a crooked Worm, exceſſive tender, and without legs. But in this Worm the diviſions or annular inciſions of the body are immediately conſpicuous, nor does it ſtand erect as the egg did, but lies on the foundation of the cell: the natural figure of the eggs may be ſeen in Tab. XXIII. fig. XI. for there ſix eggs are delineated in their natural ſize: they ſtand erect and oblong, are very ſlender, but ſomewhat thicker in the upper part; as may be ſeen under the letter *a*, fig. XII. Under the letter *b* a microſcopic view of one of theſe eggs is exhibited, reſembling the skin of a Fiſh new ſcaled; in which one may ſtill ſee the joints, ſeams, or impreſſions where the ſcales had ſtuck. Further, I ſhew in fig. X. a little part of the comb, furniſhed with nineteen cells, nine of which are conſpicuous with their erect eggs; four others contain ſome tender new hatched Worms, which have caſt their skin a little before; and laſtly, the five other cells contain Worms ſomewhat larger and more grown. I have cut off theſe little cells at one half of their heighth, that their triangular foundation on which the eggs ſtand erect, and which ſupports the Worms, may be ſeen more diſtinctly.

But I ſhall proceed, and taking up again the interrupted diſcourſe on the Bee's eggs: obſerve, that they are, until the time of their being hatched, when a kind of very ſmall Worm creeps out of them, left without the care of other Bees, and without any kind of ſitting or incubation; though the contrary opinion has been hitherto eſtabliſhed, which appears to be likewiſe in ſome degree ſupported by experience. I ſhould think, at leaſt, that the Bees go often to viſit them, that they may know for certain whether or not the Worms are come out of them. But this they can likewiſe obſerve when they follow the female wherever ſhe goes. The little cell alſo, in which the egg is repoſited, remains often to be finiſhed afterwards; ſo that in this caſe they may eaſily know occaſionally whether the Worm has crept out of the egg or not. But as the internal parts of the hive are very dark in reſpect to our eyes, and the eggs with difficulty diſcovered in the bottom of the cell, I ſhould think it follows from thence that the Bees can ſee as well in the dark as in the light, which is likewiſe the caſe with many other inſects. The eyes of the Bees indeed ſeem much better accommodated for this purpoſe than thoſe of any other inſects whatſoever; as their ſtructure will afterwards demonſtrate. For the Bees do not ſee by force of collected rays, by which the image of the object is painted inwardly on the eye; as is the caſe to demonſtration in an Ox's and Man's eye, when the external coats to the uvea are firſt taken off: but the ſimple touching and reflection of the

the rays on the external furface of the eye, evidently performs the act of vifion in the Bee.

The incubation of the egg happens only by the heat of the external atmofphere, and by the heat which all the Bees enclofed in the hive, produce by their perpetual motion; for that bufinefs is performed here in no other manner than as it is with refpect to the eggs of Silkworms and other infects, which are hatched by the natural heat of the feafon only: fo that there is no neceffity for any Bees to have the care of this; nor are there any in the hive that have the office of fitting to hatch the eggs. It is therefore an idle imagination, from which the male Bees are called brooders, or hatchers of the eggs, and has been received only, becaufe the nature of Bees has been hitherto unknown; nor has it been obferved by thofe who maintain this doctrine, that at every feafon of the year the Bees breed, and young juft hatched are therefore found in the hive before thefe pretended brooding Bees appear, which do not come forth but on the approach of a fwarm. Thus that error, at this time fo univerfal among us, arofe merely from want of obfervation. The ancients have likewife erred who called thefe Bees drones; and moreover, if we attend to what Goedaert relates of Bees in the fecond part of his Natural Met. Exper. 46, and which the learned Dr. de Mey alfo afterwards affirmed to be true in his annotations: we fhall clearly fee that the former, though he otherwife obferves a tolerable method, is; however, fo confufed and void of all order on this occafion, that his narrative cannot be really called a detail of things, but only a difordered heap of words. He there confounds the humble Bees, Hornets and Bees one with another. For my own part, I efteem nothing in the works of Goedaert but the figures; though even thofe, notwithftanding that they have been drawn according to living fpecimens, have in many inftances very confiderable faults. But it is natural to men to commit errors, nor do I think myfelf free from them, and therefore we who follow the fame ftudies are obliged to affift and bring each other into the right way, but at the fame time remembring our own weaknefs, we fhould claim no fuperiority over others. But when a perfon will not fcruple to darken the truth on purpofe, in order to depreciate another, or to favour his particular opinion, he is unpardonable. It were much to be wifhed, that Goedaert had finifhed his own obfervations.

Thofe come nearer the truth, who, knowing more accurately the nature of the male Bees, called them the more noble kind, for they in reality live on the labours of the common Bees, and are at the fame time of a more generous, mild, and tender difpofition; but that the males exclude the reft of the Bees from the act of incubation is ridiculous. The eggs of Bees evidently ftand erect, and they muft not nor cannot be without hurting them: fo far impoffible it is to hatch them by fiting on them. To which may be added, that when the egg is depofited in an imperfect cell, as is often the cafe, there is no place for the male Bee that is fuppofed to fit upon it, to reft its body, unlefs it fhould ftop up the way, and be an infurmountable obftacle to the reft of the Bees, when they attempt to perfect that cell. When the egg is at length grown mature by the natural heat of the hive, then there is excluded from it a very tender and fmall Vermicle or Worm which did not want hatching, but needs now continual and perpetual nourifhment: and not only the males, but even the females alfo are incapable of this bufinefs. To this may be added, that when thefe Worms have eaten fufficiently, if they afterwards lie in a warm place, they are fpontaneoufly and without the affiftance of any particular heat communicated by the Bees, changed into Nymphs, and then again into Bees. This I myfelf have experienced in my own chamber, with refpect to a great number of fuch Worms, fome few days after the beginning of September, before the nights began to grow cold. Nay, this experiment fucceeded fo far, that in fome cells which I had opened, I already faw the eyes of the Nymph changing, and from a limpid or clear white, becoming of a beautiful but fomewhat pale purple. This is indeed the firft remarkable change the Nymph undergoes. I have likewife obferved the fame thing in the humble Bee defcribed by Goedaert under the name of the Apis.

We fhould particularly obferve here, that there is fuch a wonderful heat in the hives, even in the midft of winter, that the honey does not concrete or lofe its original fluid confiftence, nor is gathered into grains or cryftals, unlefs in hives in which the Bees happen to be fewer than ufual. The Bees, when they are fruitful, nourifh, cherifh, and warm their offfpring in the midft of winter, and preferve a mutual heat amongft each other. But I do not know that this is the cafe in any other infects, for even the Hornets themfelves, as well as Wafps, humble Bees and Flies, are all rigid and motionlefs in the winter; and in all that feafon neither move nor change place, nor do they take any nourifhment, nor difcharge any fœces. Something fimilar likewife holds in fome fpecies of the garden and other Snails, which, when they have been about that time cleared from all excrements, by continual abftinence become a cleanly and agreeable food.

The Worm of the Bee, excluded out of its egg in this manner, and ftript of its tender skin, muft be afterwards, as I have obferved, nourifhed and fed. But as it never, like the Worms of other infects which creep about, or are conveyed elfewhere, changes that place wherein it was firft repofited in its cell; hence this Worm wants a nurfe: of this laborious care and attendance the labouring or common Bees take the charge on themfelves, and nourifh, cherifh, and bring up this tender offspring, until, from a minute Worm, like a point, it is at length changed into a Nymph, and finally to a

Bee by accretion, and when arrived to this ſtate, it is no more increaſed in bulk. The Bees indeed daily procure and provide food for theſe Worms, with as much labour and ſolicitude as birds do for their young. And it is neceſſary that it ſhould be ſo, ſince the Worms of the Bees do not ſtir out of their cells till they are nouriſhed ſo far, that, acquiring the form of a Bee, they increaſe no more. This is common to all inſects, whether they are brought forth ſmall or larger, they never increaſe further when arrived at this ſtate. Nay, this law is ſo univerſally eſtabliſhed among inſects, that after they have acquired their laſt or moſt perfect form, which they retain for life afterwards, they always remain ſmaller or larger in their ſeveral kinds, in proportion as their Worms have by force of nutrition increaſed more or leſs while in that ſtate.

However, it is neceſſary to obſerve, that it is not honey with which the Worms of the Bees are fed; it is indeed another and peculiar ſubſtance; it is of a white colour reſembling the white of an egg when it begins to harden, or a white paſte made of flower and water; it is ſomewhat thicker than honey, and is of ſo mild a taſte that it ſcarce affects the tongue. From whence the Bees obtain or bring this food, or whether it be honey which is firſt changed in their own ſtomach or proboſcis into this form, and which they afterwards caſt out, as is uſual with Pidgeons and other birds, which give a half digeſted food to their young at firſt, I have not hitherto diſcovered. Be this as it may, the Bee-keepers who regard nothing but gain, and have no knowledge in any thing elſe, tell us ſome idle ſtories on this ſubject, though they ſcarce know any thing elſe of Bees, but how much a year is to be made by keeping them. The moſt ſenſible of theſe people call that ſubſtance ſalival honey. Nor is it to be doubted but the Bees can, when they pleaſe, throw up the honey again. Clutius indeed confirms this by a very remarkable example, whereof Voſſius makes mention in his treatiſe on idolatry. If the body of the Bees be gently ſqueezed on the under ſide, the honey will be preſſed out again and make its way up through the trunk. But notwithſtanding this, a doubt remains, whether the Bees diſcharge that honey out of their ſtomach, ſince they can hide a great quantity of it in the cavity of the proboſcis or trunk: probably the ſame thing is the caſe here as in Pidgeons who diſcharge a ſubſtance like chyle out of their craw. But though honey is collected, not made by the Bees, being firſt prepared by nature herſelf in the parts of flowers, and is only taken into their bodies by the proboſcis; yet I do not doubt but it is changed, digeſted, and converted into durable and good food for the young, not only in their body, but even in the proboſcis or trunk itſelf. This ſubject it would be worth while to examine more ſtrictly: nay, what is here advanced is the more probable, becauſe we obſerve, that the honey which the Bees gather from flowers is not always of one and the ſame conſiſtence, but is found ſometimes thicker, ſometimes thiner, ſometimes watry, ſometimes aromatic in the flower, and therefore it is neceſſary that it ſhould be afterwards prepared by the Bee to render it all alike *.

To return to the ſalival or diſcharged honey. I remember that I have often ſeen a peculiar ſubſtance diſtilling from willow trees, which I am inclined to think is very like this ſalival honey, and which Hornets, Waſps, the diurnal Butterflies and Flies all greedily ſeek after. It is particularly beloved by the Butterflies, which by ſhaking their broad wings often drive away the Flies that then ſit feeding thereon. It is ſingular that I never ſaw Bees buſy themſelves about this matter, which they might have eaſily carried into their hives to feed their young. When I further conſider that the Bees in the midſt of winter, and when they do not fly out, ſtill nouriſh their young, I have no further doubt of this matter, but am convinced that the ſtock of young Bees are nouriſhed with honey, thrown out or diſcharged in a very ſingular manner from the trunks of others, whatever the Bee-kepers ſay to the contrary.

How long the worm of the Bee feeds, before it is arrived at the perfect condition of a Bee, and has legs, I am not able to determine. But if what the Bee-keepers have aſſured me, as a certainty, be true, that is, that the young ſwarm may poſſibly ſwarm again in a month or ſix weeks, then it would be no difficult matter to compute that time, and I ſhould think that according to this calculation it may be completed in about twenty-four days in ſummer. Theſe Worms, however, do not increaſe in bigneſs ſo faſt as thoſe of Flies, for they are excluded out of a very ſmall and tender egg, and have at firſt very little motion. We muſt likewiſe conſider in this matter the hotter and more favourable conſtitution of the atmoſphere; for the temperature of the air only is ſufficient to detain a Worm or Caterpillar in the buſineſs of its change, ten days beyond the uſual time. This I have often experienced. This is ſo true that the change of a Worm into a winged inſect, which in the middle of ſummer is performed in the ſpace of a month: is ſometimes prolonged to eight or nine months; this happens principally when the preceding change happens in the laſt part of the autumn; for if in that caſe the winter cold comes on immediately after, the creature inſtantly becomes motionleſs, nor does it recover motion before the next year's hot weather comes, and

* It is but of late that the ſubſtances of which wax and honey conſiſts, have been diſtinctly known; but it is now perfectly aſcertained. They are both collected from flowers. The antheræ or buttons placed on the filaments in flowers, contain a duſty ſubſtance, intended by nature for impregnating the ſeeds in the bottom of the flower, and of theſe the Bees make wax; they feed upon this ſubſtance firſt, and then diſcharge the remains, which have not been taken into the veſſels as nouriſhment at their mouths, and with a little moulding this becomes wax. The honey they find perfect in the flowers, either lodged looſe in the bottom, or in the glands called nectariæ.

nourifhment is ready prepared for it, and for its future offspring. This is alfo the reafon why feveral fpecies of infects do not die fo foon toward the end of the year as in the heat of fummer. Hence alfo, when the Butterflies of Silkworms are changed later in the year, they have fometimes remained alive with me for fix weeks after their laying their eggs, which is certainly a very fingular incident. So great is the effect of heat and cold on thefe little creatures, that the one feems to give them life and the other immediate death, for death is nothing elfe but the ceffation of natural motions. In the examples juft now mentioned, the life of thefe creatures is prolonged by means of cold, fince the ftrength of life, and the fluids on which it depends, are flower diffipated, by reafon of the flower motion. This is a fact that indeed deferves particular attention.

When the Worms of Bees are increafed to fome bignefs, they begin to fill the whole cell in which they were placed, and turn themfelves as it were into a globe, as a Dog does when he lies down to fleep; or, like that fpecies of the Woodloufe which turns itfelf round like the Hedg-hog. Now that I am upon this fubject, I remember a very remarkable ftory. One of our maid fervants had at one time found a great number of Woodlice in the garden, contracted into round balls in the manner before mentioned, and thinking fhe had found a kind of coral beads, fhe began to put them one after another on a thread, but it foon happened that thefe little creatures, which roll themfelves up in fuch a manner only for fear of harm, and appear as if they were dead, being obliged to throw of the mask refumed their motions. On feeing which the maid fervant was fo greatly aftonifhed, that fhe threw away the Woodlice and the thread, and cried out, and run away.

If the Worm of the Bee is taken out of its cell about this time, there is found under it, in the bottom of the cell, a kind of yellowifh matter of a fomewhat thick confiftence. This is the excrement of the Worm.

In the mean time, whilft the Worm is thus increafing in bulk, I do not doubt but it fometimes, like other infects, changes its skin, but how often it does this before it arrives at full bignefs, I cannot determine. I have obferved that when this Worm cafts its skin, and is changed into a Nymph, its pulmonary tubes alfo, fituated in the body, change their skin and throw out through the orifices in the body a thin pellicle. Indeed, it feems to me very admirable, that this change of skin is fo common to all infects in general, that even Lice themfelves and the minuter Mites undergo it: nay, Spiders and Locufts obey this law fo perfectly that they caft skins from their eyes, their teeth, and the very claws of their feet; even the horns are not excepted, which, though as they are fmaller than a hair in the Locufts, yet they likewife caft a tender skin. The cruftaceous and teftaceous animals alfo, as the Crabs, Lobfters, and the like, change their skins. I have likewife obferved, that when Serpents are cafting their flough, a skin is likewife thrown off from their eyes, and the inner furface of the skin is turned outwards.

At length my curiofity went fo far, that I was not afraid to tafte and bite thefe Worms of Bees, in imitation of thofe, who, from a beaftly and depraved appetite, do not fear eating the Maggots that grow in cheefe, that is, that fpecies of Worms which skip or leap by bending their bodies, and again fwiftly extending them. The Bee-Worms are of a very difagreeable tafte, like that obferved in the pancreatic juice of fifh, and they leave a very offenfive or nauceous rancour like that of rufty bacon in the mouth. Of the fame opinion with me was the very experienced and induftrious Peter Adrianus, who had then come to make me a prefent of fome male Bees, and by his affiftance has alfo greatly advanced this hiftory. When thefe Worms are boiled, they have a fomewhat more agreeable tafte; but if one continues chewing them, the former tafte prevails again.

Before I proceed further, I fhall exhibit the Bee-Worms to the life, according to the various degrees of their bignefs, as they continue growing: the thirteenth figure ferves for this purpofe. The letter *a*, Tab. XXIII. fig. XIII. reprefents a Worm juft come out of its egg, *b c d e* are Worms nourifhed longer and grown more mature; *f* and *g* exhibit others larger again and longer nourifhed, which are here reprefented in the fame manner as they lie in their cells: *i* expreffes the Worm on its back, and beginning to draw the hinder part of its body inwards, and to move its head languidly.

In the fame figure under the letter *h* I have delineated the Worm lying on its belly. In the back of this is feen a furrow of a blackifh or pale blue colour: this line fhews the ftomach, which appears through the skin in that part, which I found to be all ftuffed with a yellow matter. In the fecond figure, under the letter *a*, Tab. XXV. fig. II. is exhibited a Worm, having attained its full increafe, which ftands up at that time in its cell, and fhuts it up entirely: after this it remains very quiet and without any motion in the cell, and begins to fwell at the 1ft, 2d, and 3d annular divifions of the body, becaufe its hidden limbs, and other parts, which had increafed in bignefs under the skin, are now infenfibly fwollen with humours, and therefore difpofe the Worm to change its skin. This will be very diftinctly explained below.

If any one afterwards more accurately examines the Worm of the Bee, and views it with a microfcope, he will obferve, as I have fhewn in Tab. XXIII. fig. XIV. that it is compofed of fourteen annular incifions, *a a a*, including the head. In the head *b* are to be obferved the eyes *c c*, the lip *d*, two little parts *e e*, which afterwards become the horns, and two other little parts *f f*, fituated under the former, which feem as if they were articulated and afterwards grow into the teeth. Moreover, between thefe

two

two little parts, and consequently under the lip *d*, is presented to view another small and somewhat prominent or extuberant part *g*, which resembles a tongue or trunk; and this increasing by degrees, at length indeed constitutes the trunk of the Bee. Moreover, there is something that hangs out of this little part above, like a small nipple, by which the Worm discharges its thread to make the web, when it has eaten for a sufficient time and is going to be transformed into a Nymph. In some other Worms I have seen besides the tongue *g*, the resemblance of a small and tubular proboscis, situate in the middle between the tongue and the lip *d*, by the help of which the Worm can probably take in its meat. But I saw this last mentioned tubular little part in the Worm, when I had first pressed its body a little, and forced it forward, between my fingers, towards the head. Again, in other such Worms, I have observed a horny or bony little part immediately under the lip. But those other little parts behind this did not appear so distinctly to me. We must view these parts with a microscope, and to that purpose first separate and clear them one from another; for their colour, which is of a whitish yellow, prevents their being accurately viewed together, and in order to see them well one must use a very powerful microscope.

The two eyes of the Worm *c c* are of a transparent white, and are limpid, so that they seem inflated as it were with a lymphatic fluid. In other insects the eyes are usually brown, blackish, green, red, blue, or yellowish; and in some few of a very full or faint purple, that is, according as the tunica uvea in the internal circuit of the eyes is coloured. It is evident from this example that the eyes are not alike in all insects; nay, this diversity with respect to the colour of the eye takes place equally in the larger and sanguiferous animals: this I have particularly observed in Rabbits, in which the whole tunica uvea has been placed at the bottom of the eye, and then seemed to me, for want of blackness, unfit in a manner to detain and collect the rays of light for vision; blackness, and even a deep brown, have this property, that they never reflect the rays of light that fall upon them, and for this reason also black paper takes fire much easier in the focus of a burning glass, than that of any other colour, which reflects the rays. But the ways or means of divine providence, which can bring all things to one and the same end, are innumerable. This I shall distinctly explain in the following pages with respect to the sight of Bees; and at the same time demonstrate therein the omnipotent wisdom of God, from the eyes of these insects.

Between the two eyes, and not far from the lip *d*, occurs a part of a yellow colour; nay, the lip itself and the tongue *g* are also yellowish. In the extremities of the succeeding horns *e e* there appears also a sharp pointed yellow and brownish little part. But as all these minute parts are of a faint colour and are pellucid, they cannot be distinguished but with great difficulty.

In the other rings of the body, ten points of respiration are observed to be distributed on each side *h h h*, having no horny or bony parts of any other colour; as is the case in the Cossus, in Silk-worms, and in most other insects. It is therefore very difficult to discover these points, on account of the whiteness and general brightness of the Worm; indeed no person can accomplish his design in this case, but by frequent and carefully turning of the microscope to view the object in different lights. These points appear placed in a kind of long fissure or slit, and are somewhat depressed. The pulmonary tubes or branches of the windpipe, which are internally joined to these points, are of a clear or limpid white colour, and glitter like mother of pearl; and in some worms which are not very fat, and have therefore a very pellucid body, they are seen also distinctly through it; as is also, through the transparent body of the Worm, the stomach, which in this Worm is usually at that time filled with a yellow kind of matter like melted Bees-wax: the heart and spinal marrow are seen also distinctly through the body of the Worm, the former being placed in the back, the other in the belly.

This Worm has a very slow motion, and whenever it is disturbed, it draws its head and tail, or the posterior part of the body, a little inward. But if it be dragged out of its waxen cell, and any violence is by that means offered to it; then it will make other and more remarkable motions; for it sometimes twists and bends itself forward, and sometimes again backward. But if it be not moved or provoked, it lies without any visible or conspicuous motion; nor does it ever go out of its cell, until it hath grown into a perfect Bee.

I shall now proceed to the dissection of these Worms. The Worms of Bees, as well as other insects, may be dissected by the help of various contrivances, which I myself have often used: first, then, I killed these Worms by different methods; I boiled some of them in spirit of wine; others I steeped in the alkahest liquor of Glauber, and in divers other coloured liquors: all which I have done, the better to distinguish their internal parts, which are all of the same colour. But these did not answer with the expected success, because the Worms abound with fat. If the Worm be cast into spirit of wine, all its parts melt as it were and become watery. The parts are too much condensed by boiling, and in the alkahest liquor likewise they are in the beginning too strongly coagulated, but afterwards they change or turn into an aqueous fat or grease; therefore the best method that I know is, if one only suffocates these Worms in spirit of wine, and immediately afterwards prepare for the dissection of them. It is of service fervice likewife to macerate them in coloured liquors, till they become, as far as they are capable of it, black, red, or yellow; or they may be even left to themfelves, that they may at length acquire a colour, by a fpontaneous corruption: by this means, when the changes are properly watched, fome of their parts fhoot forth to view, which otherwife efcape the fight, or at leaft cannot be viewed diftinctly enough. It is indeed the nature of this Worm to have its body of a perfect white, and confifting of parts not very eafily to be difcerned; hence arifes the vaft difficulty of anatomizing it, unlefs we ufe the method mentioned above. All thefe things, however, need be of no confequence, if one knew how to diffect thefe Worms when alive, which yet is not eafy to be done, fince its parts contract themfelves at that time moft ftrongly, and alfo are in their own nature moft extremely tender.

If the Worm be opened along the back, immediately there appears trickling out a fort of ichor or watery humour, gufhing from the wounded veffels, and from the heart. This is the real blood of the little Worm: after this are feen the mufcles fituated under the fkin, which move the annular divifions of the body, and fome of which go into the very heart itfelf. Next is feen the fat, and among this, in the middle of the back, the heart fwelling out fhews itfelf; this is indeed a long pipe, running through the whole back quite into the head, out of which the veffels fprout branching to all the parts. This, however, I never obferved in the Worms I am treating of, but have frequently in Silk-worms. In the anatomy of the female, I fhall mention fome other circumftances about the heart: if we purfue this diffection further, prefently the ftomach rifes to view, furnifhed with numberlefs pulmonary tubes, which, being made up of fibres eafy enough to be difcerned, if it is cut, recedes very eafily from its internal coat. This to appearance is membranaceous, and is three times thinner than the ftomach itfelf; this fame tunica, moreover, like the moft tranfparent kind of glafs, is perfectly clear, as well as moft equally fmooth, which indeed is found in other infects likewife, and more than all the reft in Silk-worms. In the laft Worms I diffected, this coat, or internal part of the ftomach, was always fwollen with a fort of matter of a deep yellow colour, a little clammy, which not only filled the whole cavity of the ftomach, but in the back, where the heart is placed, was diftinctly feen through the heart and the body. In the Worms of Hornets, that inner coat of the ftomach fhews to appearance like a piece of net-work, the moft curious that can be feen, and is of a purple colour. In the lower part of the ftomach, where the pylorus lies, are four little veffels, through which there runs a matter of a yellow colour, a little inclined to whitenefs: thefe are firmly knit to the fat and air-pipes, and appear here and there through the fat, and winding about are carried over the body in wreaths; to me, indeed, it feems difficult to find out what kind of particles thefe are, for they do not appear to be like the faffron-coloured veffels, which the illuftrious Mapighius has defcribed in Silk-worms, being what I have found hitherto in all infects, though not always tinged with this yellow colour. Whatever be the cafe, after long and unwearied fearch I at laft perceive, that in their extremities, they, as the clofe guts or cæca of hens, are clofed up: to difcover this I ufe the following method, viz. with a fine forceps I take hold of the gut, or of the end of the ftomach into which the veffels run, and then flowly and carefully draw them out from the fat and intwined membranes, and pulmonary tubes; fince they could not otherwife be difentangled without the utmoft difficulty. If thefe clofed veffels are macerated for a little time in fpirit of wine, then they appear as if they were covered over with glandules, which kind of glandules may likewife be obferved in other infects. I have called thefe in the Coffus faffron-coloured veffels. In Bees it is extremely hard to bring them into fight.

The fat alfo of this Worm, as in the Coffus, confifts of globules, and thefe very globules in fome meafure refemble the globules of fat in the Coffus; but the fat in this Worm I am treating of is not loft during its growing ftate. Wherefore it may ftill be feen, after the creature is changed into a perfect Bee; if this fat be examined more accurately, befides numberlefs more minute particles, there are likewife to be obferved in it fome little oily lumps, fuch as I have before reprefented in the fat of the Coffus; but the ftructure of the fat cannot be more exactly examined, unlefs we view it laid on a very thin plate of fine glafs, a fingle microfcope being paffed between, right againft the fight. In the fat, which is mixed with extremely thin membranes, and with the pulmonary tubes, fome fmall particles are here and there feen, wrinkled and contracted, and fomewhat inclining to a pale purple, and in other parts nearly whitifh. Thefe are the beginnings of the air bladders, which afterwards in Bees are filled with air, and mix themfelves with the pulmonary tubes, to which they have hitherto but a flight cohefion; juft as the lungs in animals, that have not yet ufed refpiration, fo thefe air bladders are contracted in thefe fubjects.

On the oppofite fide, near the head of the Worm, there appear fome other veffels, which curl like the tendrils of a vine, in the fame manner as the clofed veffels juft defcribed; nay, and they are fo fimly braced with membranes, fat, and pulmonary tubes, that I have found it impoffible as yet to feparate them; whence I have alfo been unable fo accurately to difcover their ftructure. Thefe veffels are double, and at laft meet in one little tube, which, after that, fhoot on the outfide under the tongue of the Worm, and there become ftronger and tougher, and then fwell outwards in a kind of foft pimple, pervious by an opening: from this prominence a glutinous humour, the matter of the filaments, is is ſent out; ſo that theſe veſſels may be conſidered as the parts out of which the Worm draws its threads. When the Worm, having taken ſufficient nouriſhment is ſoon afterwards to be changed into a Nymph, then by the help of theſe little threads it covers in its little cell, and at the bottom, and on the ſides within, covers it over as it were with glue. I have ſeen in ſome Worms likewiſe, that theſe tubes, not far from the part where they iſſue forth under the mouth, have divided themſelves into two branches, which, however, as I have already mentioned, I have not as yet been able to trace further. In the mean time I believe, that they end in the cloſed appendages, as is the caſe in ſilkworms. Whenever theſe tubes are pierced through tne middle, in that part where they meet in one little body, there iſſues thence a glutinous matter extremely tough, and capable of being drawn out into long threads. The ſame thing is alſo obſerved in the glue of Silk-worms, not yet drawn out into threads, and in other inſects, and even in ſpiders themſelves. This, however, is to be obſerved only in thoſe Worms that are near the time of their tranſmutation into Nymphs.

I have not perceived any other parts in the Worm, beſides thoſe I have already explained, ſince the veſſels in it, which carry and return the blood, are ſo very delicate and tranſparent, that I was not able to diſcern them. For the ſame reaſon I could not deſcry theſe very parts even in the Coſſus, though there are inventions of art, by the aſſiſtance of which we may come to the knowledge of them. In Silk-worms I ſucceeded by the following method, which I have repreſented in the fourth figure, viz. I provide myſelf with a little glaſs tube, ſuch as is here delineated, which I take care to have made like a vial in the middle, Tab. XXIV. fig. IV. *a*, at one end *b* to be drawn out to the utmoſt ſmallneſs, and at the other end *c* made thicker and broader, in order that the air blowing into it, may be conveniently forced in at this end: this done, I fill the little pipe with ſome thin liquor coloured, not however of a very penetrating kind, let in through the thicker end *c*, and then with the greateſt caution perforating the ſkin *b*, I thruſt the thinner end into the heart. This may be done eaſily enough. By theſe means, and then gently blowing into it, the heart, and many of the veſſels ſhooting out from it, may be filled; and further, though no other parts are diſcovered in theſe Worms, ſtill it is of uſe to take notice in them, both of the pulmonary tubes, and the ſpinal marrow. As for the marrow, indeed, though by reaſon of its exceſſive yielding and ſoftneſs, I could not examine it with any exactneſs in the Worm, yet I had no difficult taſk to diſcover it in the male Bee, of which when I come to treat, I ſhall deſcribe it as there delineated.

There are, as I ſaid, ten points of reſpiration on each ſide of the body, in all twenty; and there is the ſame number in Silk-worms, and in the Coſſus; but there is this remarkable difference, that both in the Coſſus, and in Silk-worms, only eighteen of theſe points with reddiſh tufts, of a ſubſtance between horn and bone, ſuffer themſelves to be diſcerned; but the tenth pair of them is not ſeparated ſo plainly, which perhaps is the reaſon that the incomparable Malpighius does not deſcribe twenty, but only eighteen of theſe points in Silk-worms. The twenty pulmonary tubes, which in the Worm of the Bee ariſe as it were from theſe points, are carried inwardly into the body, and have all a mutual communication with one another: a kind of little tube runs all along from one point to another, ſo that in this manner the anaſtomoſis or inoſculation of theſe veſſels is propagated through the whole body. The ſtructure of theſe pulmonary tubes is in truth exceeding wonderful, for all of them conſiſt as it were of curled rings, which being twiſted together in the cloſeſt manner imaginable, and intwined with one another by the fineſt filaments and moſt delicate membranes, make the union ſo completely ſolid, that the air can no where pervade, except through the middle cavity, which is always open. Theſe rings are alſo twiſted cloſer in ſome of the tubes than in others, but indeed the fabric diſplays the greateſt artifice in thoſe places, where theſe pipes divide into branches and ſhoots, for there the rings are ranged with ſurpriſing ſkill one cloſe to another, and are joined together by the intervention of the lengthening, abbreviating, and crooked rings. All theſe things may be ſeen very beautifully, if one puts theſe pipes on a very thin piece of glaſs, and afterwards views them againſt the light: this is indeed a very uſeful contrivance. They may alſo, in order to diſtinguiſh them the better, be placed on thin, coloured, black, or green glaſs. Theſe pulmonary pipes or tubes are always open, as I have before mentioned, which is likewiſe the caſe in the human ſpecies, and in other animals, but principally in regard to or about the cartilaginous rings placed in the neck, ſo that therefore the air in the human body, or any other animal, which hath once breathed or reſpired, can never be entirely driven out of the ſubſtance of the lungs. We muſt further obſerve, that theſe pulmonary tubes are in this Worm diſtributed in ſuch a manner, that the brain, the nerves, and even the eyes are furniſhed with branches of them; this I ſhall afterwards ſhew in the anatomy of the eye, the ſtructure of which, too delicate for all deſcription, proclaims the infinite wiſdom of the ſupreme Architect. Next we are to explain the ſixth figure in this plate, which exhibits ſome of the viſcera of this Worm.

The letters *a a*, Tab. XXIV. fig. VI. denote the ſtomach, furniſhed with infinite air-pipes *d d*, which are affixed to it: *b* is the gullet. *c* Exhibits ſome glandulous little parts, which are ſeen diſtinctly through the tranſparent ſtomach.

ſtomach. The ſtomach alſo has towards its hinder parts ſome muſcular circular fibres *e*, which ſerve to move its contents. *g g g g* Are four veſſels, inteſtina cæca, or cloſed guts. *h h* Shew the inſertion of the cloſed guts or cæca below the pylorus *f*. *i* Exhibits the reſt of the inteſtines of the Worm, the craſſum and rectum, or the thick and ſtraight gut, to the extreme end of which a ſmall part of the ſkin is likewiſe obſerved to adhere. *l* Repreſents the delicate coat of the ſtomach, replete with coagulated contents of various kinds, which are deſigned by the darker parts in the figure. Fig. V. *a*, are the pipes appointed for the matter of the web, or the bags wherein the ſubſtance of the future threads is prepared. *b* Shews the place where theſe points are joined one to another. *c c* Exhibit the diviſions of theſe pipes. *d d d d* Is the place where thoſe pipes that contain the matter of the web are broken off, and beyond which I could not at this time proſecute their courſe: what increaſed the difficulty was, that other matters, which were likewiſe to be inveſtigated, took up all the time I then had. I likewiſe find the ſame difficulty of tracing theſe veſſels in the Worms of the Hornets; which however might have been conquered much eaſier in the latter; but it is as rare to get ſo great a number of Hornets, as a ſufficient number of their Worms.

The firſt figure repreſents the pulmonary tubes of the Worm, as may be ſeen on each ſide, under Tab. XXIV. fig. I. No. 1, 2, 3, &c. and the letters *a a a*; for twenty ſuch tubes are ſeen in this creature. It likewiſe appears in this figure, in what manner the pulmonary tubes of the ſame ſide have a communication with each other *b b*, by means of tubules carried from one orifice to the other; and have the tubes of each ſide meeting each other from the oppoſite ſides of the body, and are alſo united together *c c*. Finally, the branches are ſeen there, which ſpring from the middle trunks of theſe ſeveral tubes. The Worm is here exhibited and laid entirely open, and without its viſcera, fat, and membranes, all which I carefully waſhed off with a little water, by the help of a fine pencil. Though the orifices *d d* of the pipes are ſituated under the skin, yet I have delineated them, as if they appeared or were prominent out of it; which particular, though it be contrary to nature, yet I have obſerved in this place, that my deſcription may be the more eaſily underſtood. The other two ſpiral little parts, fig. II. and III. *e*, *f*, expreſs the rings of the pulmonary tubes. One may very diſtinctly and beautifully ſee theſe, if a hair of a man's head be paſſed through a ſmall part of a pulmonary tube, and both extremities of the hair be afterwards glued or affixed with wax; if that part of the tube be then ſeparated or taken away, with ſmall tweezers, or ſtretched out by needles, it will be ſeen diſtinctly how theſe contorted or twiſted rings are longer in one part *e* of the tube than in the other *f*. Without this contrivance, theſe rings may be eaſily diſcovered, by the help of a microſcope.

But I ſhall proceed further. I muſt obſerve, that when the working Bees have maintained the Worms here deſcribed, until they are arrived to their full bigneſs, theſe Worms afterwards abſtain from all food; and as they lay before in their little cells, contracted as it were into a globe or ball, ſo, on the contrary, they now ſtand erect, and thus fill the whole cell from top to bottom. Theſe Worms about this time, cover the inſide of the cell, from the lower to the upper part, with threads; in which work, however, this difference deſerves particular notice, that is, that the web, which lines or ſurrounds the foundation and ſides of the cell, is more membranaceous, but that which is on the extremity more thready. This difference ariſes becauſe the Worms do not always ſpin complete webs, but ſometimes diſcharge on the filaments, or thread already ſpun, a great quantity of the gluey matter, which ſhould have made the threads, and by this means daub or waſh it as with glue. This I have likewiſe often ſeen in other inſects; nay, I have had the good fortune to obſerve it even in the Silk-worms, however rare or uncommon it may ſeem; for whenever any little knots occur in ſilk thread, theſe are owing to the diſcharged matter which has flowed out too plentifully together. Nay, if the imperfect Silk-worm when expanded, be glued to paper, it does not appear thready, but alſo membranaceous; this thread is nothing elſe but a ſoft extended ſilk, afterwards hardened by force of the air. It is remarkable in the Silk-worms, that water alone has the power to diſſolve their unſpun ſilky matter; whereas, on the contrary, ſpirit of wine, vinegar, and other ſuch liquors will coagulate it immediately. In like manner as the Worms of Bees, and thoſe of Hornets perfect their web from ſpun threads, it is indeed very beautifully and wonderfully finiſhed in the end. It is perfectly white and fine above, but it is all membranous and yellowiſh below. In regard to their work, I obſerve this further difference, that the Worms of the Hornets do not draw all their webs to the ſame height, as the Worms of the Bees do; and hence it happens that their cells differ very much among themſelves in reſpect to height. Their webs alſo conſiſt of ſtronger threads, and are of a rounder figure, and uſually drawn higher than the Bee-webs, nor are they ſealed up with wax, as is common in Bees. The ſeventh figure ſhews the web, prepared by the Bee-worms; it is formed above into a ſpherical figure, and has very conſpicuous filaments, Tab. XXIV. fig. VII. *c*; but on the lower part *a* it is membranaceous and much thicker; and at length it becomes triangular, towards the baſis of the cell, and exhibits a tranſparent Nymph *b* on the inſide.

After

After the Worms of Bees have brought their webs to this degree of perfection, the working Bees have new bufinefs, for it is then incumbent on them to cover with wax all thefe cafes which are arched as it were over the head of the Worm, and confequently to feal up the Worm itfelf with the greateft circumfpection and exactnefs in its cell. This cafe feems to me to be altogether neceffary, for if the web was not covered and fealed up above with wax, it might poffibly be preffed in by the Bees running up and down thereon, and confequently the fubjacent young and tender members of the Worms which caft their skin a little before might be injured: befides that, the operculum or cover of wax contributes much to preferve the heat, by the affiftance of which, both the evaporation of the fuperfluous moifture, and the fubfequent change of the Nymph into a Bee are promoted. The web we have hitherto been defcribing has alfo this further ufe, that at the time the Bee-Worm changes its skin, and difengaging itfelf from the latter, is transformed into a Nymph, it is then prevented from flipping out of its cell, which might very eafily happen if the cells were not covered or thus fhut up, as I myfelf have learned from experiments. I at one time carried fome of thefe Worms about me, which being as it were hatched by this heat alone, came to that perfection, that the Nymphs affumed the form of Bees: I then faw thefe Bees running quickly up and down in my box, fo that I could not really help admiring what had happened: and from this experiment I learned one thing, and that is, that I might thus know for certain how much time was neceffary for the Nymph to grow into a Bee; but I have not as yet been able to inveftigate this matter fully, being then engaged in other neceffary bufinefs. I have hitherto only obferved the changes which happen under the time of growth, and at the fame time I have thus experienced, that heat alone will hatch Bees, and the incubation or fitting of other Bees is not neceffary, as fome authors have feigned. I began the experiments juft now mentioned about the end of September. If the web I have defcribed be cut open in that part where the head of the enclofed Worm is placed, the Worm afterwards will come out of it there, when upon changing its skin it is transformed into a Nymph.

The Worm after it hath covered itfelf with this web remains entirely at reft, and does not move in the leaft; it keeps the place which it at that time filled, and remains quiet to the end of its transformation. But if the diffection of the Worm be undertaken at that time, befides the cæca or clofed veffels before defcribed, there alfo appear a great number of very flender veffels, which are fituated on the inteftines near the pylorus, where the clofed veffels are inferted, and feem to me to be of the fame nature with thofe veffels which Malpighius calls vafa crocea, the faffron coloured veffels in the Silk-Worms. At the fame time the cæca or clofed veffels themfelves are feen. Whether thefe very delicate veffels are in the Worm from the beginning, and afterwards only increafe with its growth, does not yet appear. But if they be, they are much larger in the Bee than they were in the Worm: I have never found them of a yellow colour in Bees, as I have done in the humble Bees. I have fometimes feen the excrements lie coagulated in thefe veffels in the females, and indeed occafionally in the common Bees. I find great difficulty to difcover the real ufe of thefe clofed veffels, whether they fecrete a particular humour in their cavities, which muft be difcharged out of the body, or fuch a liquid as changes the contents of the other inteftines; or are they analogous to the cæca which are found in other animals, but particularly in Birds and in Rabbits? The ufe of the cæca in other animals is not yet fufficiently known, yet it is certain that excrements of the fame with thofe of the great guts are found in plenty in them. Had not thefe veffels been fo regularly divided into four, and had they been of fuch a length, and inferted even into the inteftine under the ftomach, one would incline to confider whether they did not belong to the bladder of poifon of the fting, which I fhall afterwards defcribe in the common Bee; but this doubt may be eafily folved, if one fhould diffect the Worm of a male Bee. The time for getting thefe Worms is now paft, fince I am now writing this on the firft day of September.

Further, in this ftate of the Worm the ftomach is much more contracted than it was before, and appears like a fmall gut: it is of a whitifh colour, and its yellow contents now difappear, being totally wafted. We likewife obferve, that when that Worm is but a day, or half a day older, its ftomach becomes fhorter; but the vafa crocea, or yellow veffels, are much ftronger and more vifible. A little below the place where the vafa crocea are inferted, the great guts may be feen more beautifully than in the Worm that is not yet covered in its cell. Thefe are joined to the ftomach, and now become fomewhat longer, and begin to bend or turn themfelves. Behind thefe are feen one or two parts fo tender that they cannot be accurately examined.

The fat that is found in the Worm when in its web, very eafily feparates from its membranes: hence it happens that the contracted pneumatic veffels become at this time more confpicuous.

The Worm whilft at reft in the manner juft mentioned, fwells confiderably about the breaft, but not fo much about the head; and after this it begins likewife by degrees to grow thicker, and to fwell out about the fecond and third annular incifion: the reafon of this is, becaufe the limbs of it which have increafed inwardly, are infenfibly diftended with fluids. We likewife here fee the legs and wings, afterwards the head, breaft, belly and trunk, and finally, the whole form and ftructure of the

Bee that is to be produced from thence, all ſhewing itſelf under the skin. But the legs are bent together as if they were folded up, and are weak and very tender: the muſcular fibres likewiſe are like glue, and they appear fluid like water, on account of their abundant moiſture, ſo that they can by no means move themſelves: ſo great is the extenſion and inflation which they undergo, ſo that for this reaſon, incomprehenſible changes muſt afterwards happen in them. Nor are theſe following changes peculiar to the muſcular parts alone; they are obſerved alſo in the nerves and in the ſpinal marrow, for they are likewiſe ſubject to very viſible extenſions, tranſmutations, contractions, and even tranſlocations. This is no where more manifeſt than in the Perla, or Dragon-Fly, of Mouffet, and in the Ephemerus, when theſe little inſects change their forms; for in the Perla the ſpinal marrow is extended ſo much that it becomes twice as long as it was in the Worm; and ſomething ſimilar is likewiſe obſerved in the optic nerves of the Snail.

The legs in particular, and alſo the horns and trunk *, are then very conſpicuous when the Worm of the Bee is diſtended ſo much; and by the ſame means the whole figure of the included Bee becomes, by degrees, viſible through the skin, and all the diviſions of the head, breaſt, and belly come in ſight. But at length, when the skin opens along the back, and the skull of the Worm ſeparates in three places, there the Worm aſſumes the form of a Nymph, that is, it after this change ſhews out beautifully, and more perfectly formed, the limbs and parts that were before hidden: hence all the parts may be ſeen there more clearly and diſtinctly than in the Bee itſelf; ſince that feather-like down which is ſeen on Bees, is at this time in the Nymph. The ſtructure of the trunk is likewiſe remarkable, and is moſt manifeſt here in all its parts; and therefore it can, on account of its ſituation and immobility, be much more elegantly and clearly diſtinguiſhed, than when this little inſect is become a perfect Bee, or hath been transformed into the flying ſtate, by a real growth of the parts, not a fictitious metamorphoſis, according to the fanciful and viſionary opinions of authors who have written to this time. All the changes of inſects are no more than a ſlow accretion of the limbs and parts, and therefore are analogous not only to thoſe of other animals, but alſo to thoſe which we obſerve in vegetables, as has been before ſufficiently explained and demonſtrated at large.

The creature is in this ſtate of the Nymph exceſſively, nay, amazingly tender; for almoſt all its limbs are extended and inflated with abundant humidity; the former skin is thrown off, the pulmonary tubes in the body have changed their integuments, and are again ſwollen with new air; nay, it is wonderful and utterly incomprehenſible, that the pulmonary tubes, whilſt they are caſting their integuments, do not put off ſimple membranes, but as it were entire veſſels compoſed of annuli or rings; ſo that by this means the internal pulmonary tubes which have ſeparated from the other, are thrown out of the body at the external orifices or points of reſpiration, having the ſame form with thoſe which remain in the body. In the ſame manner likewiſe the ſtomach and gullet, and the inteſtines through the whole body change their skin; which, however, is very difficult to obſerve, unleſs one ſhall immediately examine the exuvia or skin when it is juſt caſt off; or better, if we know how to take off the skin from ſuch a Worm, at a fit time, by art. The ſtomach wonderfully ſhews this in the Worms of Hornets, for theſe in like manner diſcharge their contents or excrements, and together with them the whole inward coat of their ſtomach, which is of a purple colour, ſo that the little maſs ejected weighs ſometimes more than three grains. From the number of ſuch coats as are found compacted in the cells of the Hornets, and laid on one another at the bottom of the cell, it may be very certainly computed, how many times the Hornets have brought up their offſpring from the Worm ſtate in the ſame cell.

In the Worms of the Bee it is particularly remarkable, that when they are changed into Nymphs, all their limbs and other parts, their legs, wings, horns, and proboſcis or trunk, and all the reſt of the body have pulmonary tubes: theſe tubes are likewiſe filled with air at the time their limbs and other parts are ſwelling, and by force of this air they likewiſe promote the due expanſion of the ſeveral parts: this is ſeen moſt eminently, when the Nymph, by changing its laſt skin, becomes a perfect Bee.

In the Cameleon, which is the only ſanguiferous animal that has lungs, which agree in ſome reſpect with the lungs of inſects, by reaſon of their branching pipes, the propelled air is likewiſe of the ſame uſe in expanding or diſtending the parts. But it is only for the purpoſe of extending the creature's tongue that this happens in that creature, though there are, beſide this mechaniſm, ſome muſcles that likewiſe contribute to the thruſting out this tongue: it chiefly, however, depends on the air which is forced out of the lungs for that purpoſe, into the double cavity of the tongue. I have likewiſe obſerved the organs of hearing, and the ſpleen in the Cameleon, however boldly ſome very induſtrious gentlemen in France, who have publiſhed the anatomy of the Cameleon, may aſſert that it wants theſe parts. Theſe authors have likewiſe committed great errors in regard

* Since this author wrote, the French naturaliſts have made many nice inquiries into the ſtructure of this inſect. They in general confirm the doctrines he has eſtabliſhed, but in ſome points they have improved on them. They have diſcovered that beſides the trunk, the Bee has a real mouth. This is ſituated in the fore part of the head, and may indeed be ſeen without great difficulty. By means of this the Bees are able to feed upon the farina of flowers, from which afterwards is made wax. This author thought they could not feed on it, becauſe it could not paſs their trunk; but I have taken out of the ſtomach of a Bee the farina of a bean flower in its proper form.

to

to the cornua or horns of the uterus, fince they have neither accurately delineated nor exactly defcribed them. The pulmonary tubes alfo are not reprefented acute enough by them. I would not however have any perfon think I fay this from a love of cenfure, fo far from it that my fole view is that the true face and difpofition of nature may be expofed to the eye. I wifh others may pafs the like cenfure where due on my works; nor do I pretend to doubt but I have committed many errors; it is fufficient for me that I can moft freely affert, that I have not wilfully defigned to miflead the reader in this treatife, I likewife think the fame of fome other, but very few authors; for the defire of writing is fo prevalent now-a-days, that men publifh books filled only with the fancies of their brain, and thus mifreprefent God and his works; heaven forbid that I fhould ever do this, truth and a religious fcrupuloufnefs of mind ought every where to prevail in defcribing natural things, becaufe they are the books of the divine miracles, unlefs he who writes aims to deceive himfelf and others, and fuch a one fhould know that all things are revealed in time.

Let us now return to our fubject. Thefe Worms then weave over or cover the infide of their cells with threads, they alfo difcharge their excrements into thefe cells, and there at the fame time, caft a thin fkin and their old pulmonary tubes: hence if all thefe things be done feveral times over, that is, if in the cells of the fame hive, frefh eggs be laid and young Worms be continually hatched in a fucceffion for feveral years; the cells muft neceffarily become from time to time lefs and narrower, and the Bees muft be obliged to leave the old combs, and to build themfelves a more convenient edifice: the honey alfo that is lodged in fuch foul and dirty cells, is not to be called virgin honey, nor the wax of the combs virgin wax. Since both of them abound with a great deal of filth, which ought to be feparated before they are fit for ufe. The honey which the common people ufe is very impure, for it is preffed out of wax, after the purer part of the honey has run out, and it is accordingly fold at a low price *.

If any perfon is defirous to examine the web before mentioned, let him fteep only part of it, together with the wax adhering to it, for fome days in rectified fpirit of wine; thus the wax will fall into little lumps, and the web will be manifeft alone: if an entire waxen cell, while it is yet fealed up with its Worm or Nymph in it, be put into rectified fpirit of wine, then all the Nymph's little body, which is enclofed in the web, and cannot be taken out of it, but by cutting the web, prefents itfelf to view. This contrivance whereby we fteep and diffolve the wax by fteeping or foaking it in a proper fluid, in order to fee the web, has this further advantage, that one may by this means know very exactly how many times the Bees have brought up their progeny in the fame cell, for it is certain that as many webs as are found in one cell, fo many eggs have been hatched there. When the wax is thus carefully feparated from the web by fteeping it fo that the delicate texture of it is not injured, the web will then be found to reprefent or exprefs very beautifully the hexagonal figures of the cell, particularly in the lower part, as may be feen in Tab. XXV. fig. III. under the letter *g*. This web is likewife about the bafis and angles of the little cell, always fomewhat thicker and blacker than at the upper part, being there more membranaceous and of a yellower colour: from what caufe this difference proceeds is ftill a fecret to me. If any one defires to difcover very fuddenly the web fo often mentioned, let him make the waxen cell boil for a moment over the fire in fpirit of wine, or in oil of turpentine. If an old cell be cut open with a diffecting knife, we fometimes obferve the foundation of the cell, which is otherwife wonderfully thin and delicate, half as thick as the filver coin called an imperial, on account of the feveral webs, that have from time to time been laid on it. This condition of the web has impofed on fome fo far as to make them believe, that every Bee builds its own refpective cell, for they faw that all of thefe webs were fevered from each other, when the broken wax was feparated from them, as one may eafily try if he fteeps or foaks the little cells for fome days in brandy.

The webs are alfo of this further advantage to the combs, that they make them much firmer and ftronger, and hence one may with lefs danger remove and carry elfewhere the hives in which the Bees have engendered for fome time, than thofe in which the wax is new. Befides that the combs, ftrengthened with thefe webs, do not fo eafily melt in very hot weather, or blend together, when they are turned upfide down. That the filaments or threads of the web may come in fight more diftinctly, there does not require much labour in preparing it, for if one only cuts off the upper part of one of the cells, which is covered with wax, with fmall fciffors or a fine knife, ftrips it of the waxen cover, and then places it under the microfcope, it will appear moft evident, from the difpofition and manner wherein the threads are placed over one another, that the Worm of the Bee does in reality fpin. If an entire cell, fteeped

* What is called rock honey in fome parts of America, is the produce of a peculiar kind of Bee, lodged in a very fingular manner. This Bee makes no regular comb, but notwithftanding that, it preferves its honey in waxen veffels: the honey is clear as water, and very thin. The Bees hang their clufters of cafes to a rock; one is firft made, and is very fecurely faftened; then others are hung to that, in the manner of grapes in a bunch. Thefe cells or cafes are larger than the biggeft grapes, and of an oval fhape; each has at firft an aperture at the upper part, in which the Bee puts the honey; when it is full they clofe this aperture: forty of thefe cafes will fometimes hang together, and the honey is excellent, and in large quantity.

or soaked in spirit of wine, throws off the wax, then both parts of the web, as well that which is discharged in the form of threads, as that which is like a membrane, being now joined together, nay, the whole figure of the web, which is hexagonal below, and spherical above, may be seen.

Before I enter upon the description of the Nymph more accurately, I shall beg leave to observe, that the Cochineal insect if steeped or soaked for some time in spirit of wine, appears almost like our Bee-Worm; its body being divided by many annular incisions: but there is this difference, that it is shorter and thicker than the Bee-Worm, and it also exhibits some vestiges of legs. The Cochineal Worm, as I have heard and been assured by some who spoke positively, is produced out of an egg, which the parent insect lays on the leaves of that very well known American plant called Tuna. When these Worms are first come out of their eggs, they are as small as those minute Worms which are newly produced in cheese: they are increased afterwards so much by means of the food, which they get from the leaves of this plant, that in a short time they cover the whole surface: nay, they multiply to such a degree that in the space of one year, they will occupy or possess a field that has an hundred such plants, and may be collected from thence for exportation four or five times yearly. There must only be care taken that the plants be clear of all other insects whatsoever, and that no fowls be admitted into the place; for both will greedily hunt after and feed upon these Worms. When the owner is inclined to gather these Worms, he first considers whether they are arrived at their full size, and then some throw ashes on them, and brush or gather them off the plant, and then dry them in the shade: if these Worms are left longer to themselves, they then fix themselves to the leaves when they are about to change into Nymphs by accretion: and the Nymphs, casting off some time after a thin skin, are changed into very small and almost orbicular winged Beetles, of a brown black colour, adorned with bright purple spots, and distinguished into males and females, who soon after coition lay eggs again. These Beetles are not, like the Worms, used in dying, though they are sometimes brought to us mixed with Cochineal, as I myself have seen, and now have some that I picked out of that drug in my custody.

In our country also on the leaves of the lillies, Worms are often found which are somewhat thick and of a pale red colour, like Cochineal, but they differ from it in that they are furnished with six remarkable black legs, and have a very conspicuous head. These Worms are transformed in a very short time into an oblong bright red Beetle with black legs and horns. This Worm has one thing peculiar to it, which is that it covers itself with its own excrements against the sun's heat, and by that means renders itself in a manner invisible; since it walks over the leaves of lillies covered with its excrements. I have likewise in my collection of insects some little creatures not unlike the Cochineal Beetle, only that they are somewhat less and in some measure different in regard to their colouring. Hence I am inclined to think that the Cochineal may probably be discovered and fed in our country, though I have never yet found it. This species of Beetles, which have all knobbed horns, are by our country people called Lieven Heers Haantjes, or Onze Vrouwen Haantkens: but I shall now return to the Bees.

The Nymph of the Bee-Worm contains nothing else but an elegant disposition and well-ordered representation of all the limbs and parts of the future Bee; which, as they have been to this time increasing, at length become externally conspicuous; but they are immoveable until the humours with which they are filled and distended are exhaled and dissipated: after that the creature can move them. Hence it is that the Bee while in the Nymph weighs considerably more, than when it is changed into a perfect Bee. Before I exhibit the parts and limbs of this Nymph, I shall describe its parts while yet in the Worm, with more accuracy and method than has been hitherto done by others. In doing this I shall follow the order according to which the Worm insensibly and naturally approaches to the change of its skin, or to the disclosure of these hidden members: it is as follows. The old skull, which is to be immediately cast off, becomes insensibly filled with a limpid humour, by force of which it is separated by degrees towards the foremost parts from the head; hence the horns, teeth and trunk, which lie folded and complicated together under the skin, are disposed in such a manner, that they may be extended and inflated by the imbibed humour, all which happens gradually; in the mean time the head, which insensibly and in a manner scarce to be perceived, recedes or goes back from the skull, is gently extended and expanded; this is principally occasioned by the eyes and their adjacent parts being inflated or distended with air, blood, and other fluids rushing in; the thorax likewise now becomes extuberant, by reason of the air and fluids introduced; as do also the legs themselves in like manner swelling considerably both above and under the thorax; they are placed in a very elegant manner under the skin: the first or foremost pair of legs adhere underneath near the proboscis, which together with all its parts is stretched upwards, to the head in such a manner, that the extreme ends are in the upper part, and the thighs in the lower place; then follows the second pair of legs which are deposited in like manner; near these the wings are situated, whereof the less are placed by the sides of the greater and a little under them; then follows the last pair of of legs, which is depofited in the fame manner as the firft and fecond were under the skin ; all thefe parts, as far as they lie under the skin, are fomewhat wrinkled or folded, and they are by this means above one half fhorter than afterwards when the creature is changed into a perfect Nymph ; for when the Worm cafts it skin, thefe parts are confiderably and wonderfully inflated and extended by force of the air, the fluids, and particularly of the blood : this extenfion of thefe parts is performed at the time when the Worm, by the means of a kind of periftaltic motion, breaks open the skin by rolling it down, and is incredibly promoted by the parting exuvia or caft skin ; for fince all thefe parts by means of delicate and minute fibres and filaments adhere loofely to the skin ; hence the skin carries them with it as a kind of moveable cords, and the parts themfelves being by this means extended, roll in their turns from the skin in the fame manner as a cord runs out of its pully. This is the true reafon why thefe parts are fo regularly digefted and extended in the Nymph, and are difpofed in fo beautiful and firm an order and fo wonderful a fituation as I am now going to defcribe, according to the figures which I have given. I fhall firft then fhew in a fomewhat fmaller figure the difpofition of the parts under the skin, a little removed from their firft fituation. Tab.XXV. fig. IV. *a a*, are the horns, *b* the probofcis with its parts, *e e* denotes the firft pair of legs, under which is feen a fecond *f f*, and then a third *g g*; *h h*, *i i* are the larger and fmaller wings of each fide : *k* denotes the rings of the abdomen. I fhall in the ninth figure reprefent the fituation of thefe parts in the Nymph in a larger fcale.

Fig. IX. *a* Reprefents the Nymph's head, which being then diftended with humours, and expanded by force of the impelled air, refembles in foftnefs and tendernefs, milk that is juft curdled. In this manner the whole body and all the reft of the parts are circumftanced at this period. All thefe parts are of a milk-white colour, and the whole infect is without any the leaft vifible motion; fo that in reality, it refembles a dead carcafe.

b b Exhibit the eyes of the Worm, which now appears under the form of a Nymph. Its three fmaller difperfed eyes cannot be feen in this view, being placed more backward and higher in the head, in the middle between the larger eyes. The firft change obfervable in this creature, when it becomes ftronger by the evaporation of the moifture is manifefted about thofe fmaller eyes, and about the large ones here figured *b b*. Their change confifts in this, that the eyes, by degrees and as it were, infenfibly affume a faint purplifh colour : at the fame time is alfo difcovered the femi-lunar figure of thefe large eyes, which one cannot otherwife difcern, on account of the intenfe whitenefs which obtains here, and the brightnefs of the furface.

c c Are the antenne or horns which fpring from the middle of the head, and are bent by force of the skin that is drawn down towards the belly ; they are very elegantly placed near the probofcis and its adjacent parts. Under the extreme ends of the horns are difpofed the three firft joints of the firft pair of legs *i i*. In the middle of thefe one may fee numerous pulmonary tubes through the covering.

d Denotes the lip, which is not yet remarkably increafed in its fize, or diftended.

e e Are the teeth or jaws, which are covered in fome meafure by the lip.

f f Shews the firft pair of thofe parts which belong to the trunk or probofcis: they have likewife their pulmonary tubes, but above them and under the teeth is feen a certain portion of the third or laft pair of thefe little parts belonging to the trunk, which are the fhorteft and fmalleft of all.

g g Reprefent the articulated pair of little parts that defend the probofcis, which are divided on each fide into three joints.

h Is the probofcis itfelf, very beautifully fituated between and under the faid parts. But we muft obferve, that all thefe little parts are now furnifhed with tranfparent pulmonary tubes. When the little infect is approaching to its laft change, and is in a fhort time after to obtain the form and name of a Bee, then all thefe pulmonary tubes become again for the moft part invifible. And the fame thing obtains about the veffels of the wings: which are then bound or tied up in fuch a manner, that you would conclude them not to be pulmonary tubes but nervous fibres.

i i Exhibits the firft pair of legs in the Bee, while it is ftill called a Nymph. The three extreme joints of thefe legs may be feen under the extremities of the antennæ *c c*.

k k Are two very beautiful, ftiff, tranflucent little parts, fituated at the loweft joints of the firft pair of legs, and which feem to ferve the Nymph only as an ornament ; for upon cafting the skin, they are thrown off and entirely abolifhed.

l l Another pair of the Nymph's legs, which likewife are full of tranfparent pulmonary tubes. Thefe legs, being, by means of the skin when drawn off, and by the power of the impelled air and forced humour, depreffed and ftretched beyond the middle of the body, are there very regularly placed.

m m Are the wings of the Bee, ftill conftituted under the form of a Nymph, a part of which only we can hitherto fee. Thefe likewife have many pulmonary tubes, which, when this Nymph is cafting its laft skin, are alfo, together with all the other parts, once more to throw off their exuviæ : after which, when thefe tubes are again diftended by the frefhly impelled air, and the pneumatic veffels which have been hitherto contracted, are inflated and diftended with the fame air; it follows, that the whole wing afterwards expands itfelf and becomes

becomes thrice, nay, four times larger than it was before. But this expanſion of the wings is not to be attributed ſolely to the air, but in a conſiderable degree alſo to the blood; for at the time when the air is impelled into the wings, and a conſiderable quantity of blood is likewiſe driven into the blood veſſels of the wings. This blood in the Bee is a limpid humour or ichor, as may be obſerved, if a little part be at this time cut off from the wings; for then this humour flows from it, appearing by reaſon of the extreme ſmallneſs of the blood veſſels, under the form of little pellucid globules, which, inſenſibly and by degrees, increaſe into conſiderable little drops. We muſt obſerve here, that ſome of the Nymphs of Flies, when they are caſting their skin, not only expand their complicated wings, but alſo diſtend vaſtly their whole body: hence it ariſes that they appear twice as big as the exurvæ, wherein they were before encloſed. The expanſion of the wings in Butterflies is the moſt elegant of all the phenomena of this kind that occur in nature; for in theſe creatures, the wing in the ſpace of a quarter of an hour, though at firſt not bigger than half the nail of one's little finger, becomes as broad as a half crown, and at the ſame time all its colours are augmented, extended, and regularly diffuſed: and hence indeed, an admirable ſight is produced, which would appear the more wonderful if one had but the leaſt knowledge of the cauſe of it. For we certainly can know nothing of the magnificence of nature's ſecrets, unleſs by the help of an infirm and weak reaſoning we are able to paſs our judgment on the more evident and palpable effects; but even this is ſubject to many errors. When the wings are diſplayed in the Butterfly, their air-pipes or pulmonary tubes are ſoft like warm wax, and the wings hang down that they may the more eaſily be diſtended with air and humours.

Tab. XXV. fig. IX. *n n* Are the ſcapulæ or ſhoulder blades of the Bees Nymphs, which are ſomewhat ſharper a little lower. Under theſe are ſeen a pair of orifices, by which the air-pipes open into the breaſt. The air which is expelled through theſe orifices aſſiſts in producing the humming noiſe which the Bees make with their wings.

o o Exhibits the laſt pair of legs, which are likewiſe furniſhed with tranſparent air-pipes like little veins.

p p Are the rings of the abdomen, in which ſeven apertures of air-pipes open on each ſide. But I have not delineated theſe apertures in the preſent figure; ſince I do not yet know their true ſituation, for they appear very obſcure, becauſe only one colour is ſeen here. However, I have obſerved in diſſecting the Nymph, that the mouths of theſe air-pipes terminate in the rings of the abdomen. I have ſeen alſo three ſuch orifices in the breaſt. I ſhall now mention ſome other things in the anatomy of the Nymph, which are pertinent to this matter.

q Exhibits the hinder or poſterior parts of the Nymph. The ſting of the future Bee is ſeen there ſomewhat protuberant out of the body, as are alſo thoſe two little parts *r*, which accompany the ſting in the common Bee and in the female. And laſtly, the arms appear underneath *s*.

If all theſe parts be afterwards removed out of their places, then the diviſions of the head, breaſt and abdomen appear very beautifully in the Nymph, but moſt particularly thoſe of the breaſt: and thus we may at the ſame time beautifully ſee how the legs are jointed with the breaſt, which cannot be diſtinctly ſeen in the Bee ſtate of this little inſect, on account of the great quantity of down riſing there. If the creature be then inverted ſo as to lie on its belly, the three great diviſions of the body are manifeſtly ſeen in it: and in the horny or bony parts of the thorax, which are ſtill membranous, and very tender numerous air-pipes are likewiſe obſerved.

The firſt external change obſervable about the Nymph conſiſts in this, that its eyes inſenſibly become of various hues. Firſt of all are diſtinguiſhed thoſe three remarkable ſeparate eyes, which, when the inſect lies on its back, are ſeen fixed between the ſemi-lunar curvatures of the larger eyes, as I ſhall hereafter explain more at large. And at the ſame time, the ſemi-lunar figure of the eyes is conſpicuous by their variety of colours. Nor can any other remarkable change be obſerved at that time in the Nymph, beſides this of colour, which occurs in the three ſeparate and in the ſemi-lunar little eyes.

When the eyes by degrees have grown purpliſh, then ſome ſmall changes are likewiſe ſeen about the body and legs; that is the horny or bony parts of the ſhoulder blades begin to acquire a yellowiſh tinge, ſomewhat inclining to a brown red: the horny or bony parts of the wings, legs, and the reſt, then afford alſo ſome ſmall ſigns of their transformation.

Whilſt the colour of the limbs and parts is changing in the manner I have mentioned under their accretion, the purple colour of the five eyes become more and more brown, and at the ſame time we obſerve, that the claws of the feet become alſo horny or bony, and of a brown red: and this change is alſo obſerved about the teeth.

In the mean time the eyes become, by little and little, more blackiſh, nor is there yet any diviſion in the coat that inveſts them on the outſide, though one may then eaſily ſee the diviſions which appear through the coat. The horny or bony parts of the trunk now alſo begin to grow black, and the horns, which are ſituated under the eyes, and the diſtinct eyes above are more plainly ſeen.

The thorax alſo is about this time from a gray, manifeſtly changed into a browniſh colour: and we alſo ſee the whole body under the skin, diſtinguiſhed by ſome blackiſh fome blackifh points, which are the rudiments of feather-like hairs.

Whilft the whole body is changing in this manner, it is altered or difguifed, and becomes more robuft as it is increafing; fo that even the claws of the feet now evidently move within the skin wherewith they are furrounded; but the moft remarkable changes are obferved about the fting. For this fting is hitherto an external part, though it may afterwards be, and actually is drawn back into the body: therefore, fince it is confpicuous in the Nymph without any previous diffection, one may eafily obferve its increafe and perfect formation. The better to underftand my obfervations on this part, I think it neceffary to obferve before-hand that the fting, as well as all other parts of the body, changes its skin when the Nymph throws off the laft exuviæ: for this reafon, the changes of the fting may be diftinguifhed as clearly as thofe that happen in the claws, legs, and the teeth. The firft change, therefore, which is obferved about the fting, confifts in this, that its crooked little hooks, which neceffarily remain fixed in the wound given by the fting of a Bee, come in fight. For while the two fide-pieces, and the cafe or fheath of the fting are yet membranaceous, or as it were cartilaginous, thefe little hooks are diftinguifhed by their yellowifh red colour; and this colour is afterwards diffufed by degrees through the whole fting, whilft in the mean time the fharp-pointed ends of the two fide-pieces of the fting, are acquiring a horny or bony fubftance, and more dusky colour. The circuit alfo, or extremity of the cafe or fheath of the fting, in like manner changes its colour, grows hard, and becomes horn-bony. And as the other parts ftill retain their white colour, the faid changes ftrike the eyes the more plainly: for we muft obferve that the fting is, with regard to its colour, more confpicuous in the Nymph, than it is afterwards in the Bee itfelf. Moreover, the two fide-pieces, as well as the fheath of the aculeus, are enclofed in peculiar membranes, which are thrown off in a moft fingular manner: hence one may very diftinctly fee thefe fide-pieces in the Nymph placed near each other, which is by no means the cafe in the Bee; fince thefe parts of the fting in that ftate of the infect are hidden in the cafe or fheath, as I fhall hereafter defcribe at large, and reprefent in figures. About this time, alfo, thefe feveral parts, as well as all others, acquire each their laft perfection; that is, the eyes, teeth, legs, claws, horns and the reft: nay, the thorax itfelf infenfibly becomes during this time more brown, and approaches nearer to a horny nature, and grows very fhaggy with ftrong hairs.

The laft change happens in regard to the ftrength and colour of the wings: at the fame alfo the probofcis or trunk in like manner prefents itfelf to view in its ruddy or bright brown colour, and fhews the hairs wherewith it is adorned. Thus all the fuperfluous humidity of the Nymph being at length evaporated, it cafts a skin from all its parts, and after gnawing a paffage through the web, creeps forth at length from its cell, in which it had hitherto lain, in its perfect form of a Bee. The wings indeed are at that time ufually complicated or folded up, and yet I fometimes have feen them expanded; that is, when it hath been for fome time detained in its waxen habitation, and hath not been able to creep out of it with fufficient fpeed: in that cafe we find that its wings have been firft difplayed within the little cell: all the fpecies of Flies appear in like manner, when frefh from the Nymph, with complicated wings.

When I diffected the Nymph of the common Bee, at the time that its colour juft began to be vifible, upon opening the outer skin, I obferved the fat feparated very eafily from the air-pipes or pulmonary tubes; which was likewife the cafe about the outmoft coat of the eyes, which has no divifions. All the contents of the eye alfo were very foft. The inverted pyramidal fibres hereafter to be defcribed, refembled jelly made of veal. The brain was likewife fo foft that being only very lightly touched, it immediately feparated from the beginning of the fpinal marrow. The fpinal marrow itfelf was there as well as in the body very foft and tender. Nay, and the three feparate little eyes, which, as fhall be made more evident hereafter, are placed in a triangular form between the divided eyes, after I had taken off the skin from them, and can be diftinguifhed very clearly. The teeth were as yet membranaceous, nor did they fhew any fign of hardnefs, or of their being of a horny or bony nature; they abounded within with a mucous humour, upon preffing out which they feemed hollow. The jaws in human abortions fix months old, likewife fhew membranaceous teeth, which however in various places are obferved to be growing into bone.

In the thorax all things are at this time amazingly foft and tender. The mufcular fibres may be feen very diftinctly, and in fome meafure as if feparated from each other; but they are ftill fo exceffively delicate, that being but very gently touched, they immediately quit the place where they were fixed: moreover, they are at this time fhorter than in the fame infect when it is changed into a Bee. Indeed, I obferve that all thefe mufcular fibres are at firft contracted in the fame manner by nature, and that in fpite of her, as it were, they are afterwards extended by the blood and humours. This is probably the reafon why thefe fibres endeavour to contract themfelves continually, and that even a long time after the death of the creature. This fhortnefs of the mufcles in creatures not yet brought forth, is occafioned by the invefting membranes binding up their bodies; and hence it happens that the blood and air are prevented from diftending the mufcles fufficiently. We have before mentioned fome fingular and obvious examples of this matter in infects, which are feen as foon as thofe creatures come into the open air. The fat alſo very eaſily in this diſſection of the Nymph quitted its connecting membranes and the pulmonary tubes, and, by its friability, preſently hid the other parts from ſight, for it divided and diffuſed or ſpread itſelf into innumerable white parts of different bigneſs. Between this fat were likewiſe ſeen the pneumatic veſſels, not much changed from that appearance which they had before in the Worm, when it was about to caſt its skin.

The ſtomach in this Nymph appeared ſtill ſomewhat long, for it had not wholly contracted or drawn up the length which it has in the Worm, into the pyriform figure which it wears in the Bee. All the reſt of the viſcera of the body were already formed and conſiderably increaſed. The inteſtines were very elegantly conſpicuous, and of moderate ſtrength, but they were filled with watery contents, nor did they yet contain that green ſubſtance, which is to be found in the inteſtines of the more mature Nymphs, and thereof the green colour is evidently ſeen through the body and heart in the back. The ſame thing obtains in calves whilſt ſtill in the cow's belly, and the contents of the inteſtines in them in like manner change colour. It is alſo very remarkable here, that ſuch hairs are found intermixed with thoſe excrements, as the mouth and body of the calf is covered with; and this argument moſt evidently demonſtrates, as I have obſerved before, that theſe animals convey the food while in the uterus through the mouth; nay, and take in the hairs which they licked off the ſurface of their body, together with the fluid of the amnion. The vaſa crocea, or yellow veſſels alſo may be very eaſily diſtinguiſhed in this Nymph, and ſeparated eaſier from the inteſtine, than in the Bee arrived to its full maturity; for, beſides the friability of the fat, the membranes are yet very tender, and the pulmonary tubes, to which theſe veſſels are connected, are very weak. The internal parts of the ſting alſo, which are not viſible on the outſide, may be now very plainly diſtinguiſhed. It was further admirable to ſee in this diſſection the aculeus or ſting, which afterwards becomes ſo ſharp-pointed, hard and formidable for wounding, is ſtill very ſoft and tender, like a thin membrane, and is likewiſe filled with an aqueous humour, which naturally flows out of it. The poiſon bag * of the ſting was contracted, and its cloſed tubes, by the help of which the poiſon is ſecreted and conveyed into the bag, may now alſo be diſcerned.

But as all the parts hitherto mentioned were extremely ſoft and yielding at the time of this diſſection, ſo, on the other hand, the productions of the wind-pipe, or little pulmonary tubes, preſented themſelves more diſtinctly to the view. The reaſon of this, as I have before obſerved, is certainly that the fat and the membranes which connect it, recede from theſe parts with the utmoſt eaſe: we lay open the Nymph from the bottom quite to the top with a ſmall pair of ſharp-pointed ſciſſors, all the fat, the little membranes and the reſt of the contents may be without any difficulty, in a baſon filled with water waſhed out ſo thoroughly, that the pulmonary tubes alone, though they indeed, with reſpect to their larger branches, are not removed from their natural ſituation, ſhall remain behind in the skin. The ſame experiment may alſo be made in another manner, viz. a fine glaſs tube may be thruſt into the body of the Nymph, and by the help of water injected through it, all the contents, except the tubes that convey the air, may be waſhed out of the body. This may likewiſe be done alſo in the Worm, when it is on the point of changing its skin, and then being blown up with air it may be dried and preſerved. The ſame experiment may be made with the utmoſt eaſe in the melts of oxen; for if you waſh off the outermoſt ſubſtance of the melt through the vein, and then cut away with a fine knife the exterior coats from the melt when dried, you will have a moſt curious preparation. At this time we have a moſt beautiful view of the pulmonary tubes, and their ramifications in the Nymph of the Bee; ſo that they may with very little trouble be counted and diſtinguiſhed from one another; ſeven appearing plainly in the belly, and three in the breaſt on each ſide. The firſt pair of theſe open with fair apertures on the outſide in the breaſt near the neck; but before theſe two tubes aſcend from thence towards the head, having firſt taken a wider circuit, they join together, and then in two very diſtinct branches, like the carotid arteries in man, they again aſcend towards the head, inſerting themſelves in the brain, the eyes, the horns, and the teeth. The next two orifices are opened under the ſhoulder-blades, and the laſt under the wings. Some branches likewiſe, and thoſe very diſcernible, run different ways out of the breaſt towards the legs and wings; and theſe at the laſt changing of the skin aſſiſt greatly in the unfolding of theſe parts, as I have already obſerved. In the belly I could not ſo accurately diſtinguiſh the orifices of the pulmonary tubes on the outſide, for there they ſeem to be inſerted obliquely, like the urinary paſſages in men and quadrupedes. But however, in the inſide of the body their inſertions are extremely obvious: this may be ſeen alſo even on the outſide, if we free the Nymph from its coat or ſtrip off its skin with due skill, and then draw the air-pipes out of their orifices. As for the poſition of theſe pipes in the body, I have already ſpoken of it elſewhere, and ſhall explain it farther in a ſucceeding chapter.

* The poiſon of the Bee ſeems to owe its miſchievous efficacy to certain pungent ſalts. It may be eaſily ſeen to contain ſuch. Let a Bee be provoked to ſtrike its ſting againſt a plate of glaſs, and there will be a drop of the poiſon diſcharged and left upon the glaſs. This is to be placed under a double microſcope, and as the liquor evaporates the ſalts will concrete. They form oblong, pointed, clear cryſtals, but the quantity of fluid is not enough to let them form diſtinctly.

The

The Nymphs of Bees, after they have continued ſhut up in their little waxen cells for a ſufficient time, and till the entire evaporation of the redundant moiſture, ſhed at length their laſt ſkin of all, which accordingly is found in the bottom of the cell, together with the former, which they have thrown off during their exiſtence under the form of a Worm. Having thus caſt their coats, they then break their web, by the aſſiſtance of their teeth, and at the ſame time forcing their way through the wax that is faſtened down above to the web, and burſting it into ſeveral jagged pieces, they throw it off on all ſides; after this other Bees carry theſe broken pieces away, and clear the cells ſo thoroughly, as to make them quite ſmooth and even. The male, as well as the female Bees, force their way alſo out of their cells, in the ſame manner as the common or working kind, and all undergo the ſame change. This remarkable difference, however, is to be obſerved, that the common Bees, and of the male kind alſo, uſually come forth, as already obſerved, with their wings then folded up; ſo that after they have burſt through their webs, their wings remain yet to be expanded, by the force of air and humours impelled within; for, as has been already obſerved elſewhere, thoſe large veſſels, which are perceived in their wings, after the manner exhibited in Tab. XXV. fig. x. are without doubt the tubes that convey the air. Cloſe to them alſo are placed the blood veſſels, which bring the nutriment to the wings. This obſervation I have made is highly worthy of notice, ſince it moſt evidently diſplays the wonders of God, in the inſect world, and at the ſame time utterly overthrows thoſe impious notions, that theſe creature are generated from putrefied matter, and by a certain fortuitous concourſe of particles; for if we grant that, the eſpouſers of theſe notions take occaſion thence moſt perverſely to carry on the argument to large animals, and in a moſt offenſive and indecent manner leſſen and detract from the providence and omnipotence of God, which are univerſally and equally manifeſted in every ſpecies of animals without exception. In truth, if the moſt minute creature is capable of being generated from putrefaction, nothing hinders but that the largeſt of all may likewiſe.

The female Bees do not, as the common Bees and the male, come forth with their wings folded up, but expanded and diſplayed: they come out of their cells in a ſtate of flying. On this account, the all-wiſe Author of nature has provided for them a more ſpacious manſion, in which they may expand their wings conveniently and properly, ſo that after they have burſt from their cells, they may be prepared for ſwarming immediately, if there be a neceſſity for it, or that the young female may be in a condition to drive out even the mother Bee herſelf, that is the old female, and to take her place, if there be occaſion.

I am fully perſuaded that the reſt of the Bees know beforehand, by ſome ſure ſign, when the new female is employed in breaking through her cell; and, accordingly for ſome days before they form a new colony or ſwarm, we ſee a great many Bees hanging about her cell, which are no doubt waiting for the female's iſſuing forth, and when ſhe is juſt on the point of coming out, they make a buzzing with their wings, which is the ſong of Bees, receive and ſalute her at a diſtance as it were with marks of joy. I make no doubt but that the males are moſt concerned in this buſineſs; not unlike wanton horſes, who, when they ſee the mares, though at a diſtance, neigh after them, and inſtantly prepare themſelves for leaping. This is the caſe likewiſe in the males of Silk-worms, which, before they ſo much as ſee the female, yet immediately, as ſoon as they get the ſcent of her, by the help of their wings ſet up an agreeable humming; and ſo irritated are they with a burning deſire for copulation, that they will frequently copulate with the females even when dead, nor can they without force be torn off. However, I do not believe, that the male Bees actually copulate with the female, though indeed they love to get as cloſe to her as they can, becauſe thus they feel a titillation ariſing from the emiſſion of their ſperm. For I am firmly perſuaded, that the male Bees eject their ſperm in the ſame manner as Fiſhes, who only ſhed it upon the ſpawn, nor have any thing further to do with the females. It would be no difficult matter to make certain experiments, in all theſe particulars; as to try for inſtance whether the female Bee, encloſed in a little net made of fine thread, or in a ſmall glaſs veſſel covered with a piece of fine linen, or in a box with holes in it, could be impregnated by the bare ſcent of the male. But of all theſe things I ſhall hereafter treat more at large. I think it neceſſary, however, to add this ſingle obſervation, that the laſt humming or noiſe which is heard in the hive, a little while before the Bees are going out to ſwarm, is raiſed by the female Bee alone, ariſing to be ſure from her joy in feeling herſelf then impregnated, and being ſenſible that ſhe is ſoon to make an excurſion; ſince the ſound, which is then heard, is owing only to one Bee, and that no other than the new queen.

I once found a female turned quite upſide down in her cell, and yet perfectly formed with her wings already expanded for flight. She had been attempting a paſſage on the oppoſite ſide of her cell, endeavouring to break through the middle wall of the comb itſelf, great part whereof ſhe had already eaten through: ſhe ſeemed as if ſhe would be able to get out of the cell in a few days. In theſe difficulties I came to her aſſiſtance, and at the ſame time got myſelf a proper ſubject for diſſection. When the Bees begin to perceive that the female is near coming out of her cell, I make no doubt but there muſt ariſe a very remarkable commotion in the hive, as well

well amongſt the younger as the older Bees; for the young follow the new-born female, and the others remain with the elder; nay, many both old and young hang together idly round the ſame female. This diviſion into parties is not owing either to choice, or any ruling power or authority among the Bees, nor is it performed with thoſe fancied ceremonies of honour, and a numerous retinue of old and venerable Bees ranged in order, accompanied with the harmonious ſounds of trumpeters, hautboys, and muſicians, or in the tremendous preſence of executioners ſtanding around, as authors have feigned, ingeniouſly indeed, but derogatory to nature. Nothing like this is the caſe: there is doubtleſs implanted in them a concern for breeding up their young, which inſtinct makes the Bees flock in this manner round the female: nor have the tribe of ſlaves, I mean the working Bees, any other task aſſigned them, as they are capable of being moved by that incentive only, and direct all their actions to that end, though in truth the labour is very great, which they muſt undergo in breeding up the young, and continually building the cells deſtined for them. However they are amply repaid, ſince in their turn, in place of a rich reward, they feed on delicious honey, which they collect with indefatigable diligence; for nature, in this their wretched ſtate of life, makes every thing to be purchaſed with labour. I could wiſh therefore that this example had the weight it deſerves, in inſtructing and teaching us that God might be glorified in all his works.

Were the working Bees furniſhed with the organs of generation, or any thing analogous to them, we might conclude, not without probability, from their actions, that they were actuated with the moſt ardent luſt to the act of generation, and ſolely by this incentive animated to perform the ſeveral tasks aſſigned them. But ſince they are ſupplied with none of the parts requiſite for that office, they can have nothing elſe in them, but an innate deſire for the propagation of their ſpecies, which inflames them with ſo earneſt a concern for breeding up the young, and with ſo ſingular an affection towards the female, the common parent of all. This will appear evidently, if you take this queen out of the hive, and tie her to the end of a ſtick, by a thread run through one of her wings, and then ſuffer the ſwarm of Bees to fly about her; for they, following the queen cloſely, will all of them by degrees ſettle on the ſtick, and by the help of their legs cling to one another moſt ſurpriſingly, ſo that they reſemble, as it were, a complete bunch of grapes. When they are piled up together after this manner, they will ſuffer themſelves quietly to be carried up and down over a whole garden, nor do the working Bees in the mean while ſtir from their queen, as I myſelf found by a careful experiment I made. If at this time any other Bees fly up to this numerous cluſter, an obſerver will ſee plainly, that they immediately ſearch after the queen with ſuch anxiety, that even from hence ſufficiently appears the prodigious affection they have for her, and for the propagation of their ſpecies; for they endeavour to make their way through the middle of the bunch, as it were, that they may reach the female. In a little time afterwards they give over their attempt, and then, without intermiſſion, continue flying from and back again to the cluſter. From theſe obſervations therefore it is altogether manifeſt, that the actions of Bees of the three kinds, male, female, and eunuchs, ſpring from no other cauſe, but from a vehement and ardent concern, by which they are carried to the generation, preſervation, and raiſing of the brood, which, as it is alone the principle, ſo likewiſe is it the end of every thing the Bees do. If after this the female be looſed again from the ſtick, and immediately put into a drinking glaſs, placed on the ground, or on a piece of tile, the reſt of the Bees, to a ſingle one, will inſtantly ſurround her again, and beſet the place where ſhe is in ſuch throngs, that one can ſee nothing but Bees covering it on every ſide. From all this I think it may be inferred, not without an appearance of truth, that the female emits a very ſtrong ſcent, by which the reſt of the Bees are attracted to her. I obſerved this moſt evidently when I had ſhaken the ſtick, and had laid the female in the manner abovementioned on a table, in an open arbour, at ſome diſtance from them. For this reaſon I formerly, before I was acquainted with the true ſtructure of the common Bees, compared them to a parcel of Dogs, which follow the female in her time of luſt, excited by the bare ſcent; however, I will not deny, but that there may perhaps be ſomething elſe beſides the ſcent in this affection of the common Bees, by which they are ſo greatly affected: they ſeem to imitate in ſome manner creatures that have been gelt, which, though they can do nothing, are notwithſtanding inflamed with a prodigious luſt for the female.

As therefore it is generation alone by which the Bees are excited to all their actions, ſo this great cauſe, whenever it happens to be interrupted, is the ſole motive from whence all the confuſion at times obſerved in the hives ariſes. If the female Bee be barren, or maimed, crippled, blind, or deprived of its wings, neither honey nor wax will be collected, nor will the eggs be laid in the cells. There is in this caſe no occaſion for building cells for rearing up the brood. But if the female be properly perfect, every thing is done in due order, and as the poet ſays,

> " While the ſovereign is ſafe, all live in
> " perfect harmony." Virg.

A great diſturbance is alſo to be obſerved, whenever there chance to be two females in one hive, and one after another lays its egg in in the ſame cell, for from thence ariſes not only a vaſt confuſion about the article of raiſing the young, but a mighty inconvenience likewiſe about the building of the cells. It ſhould be here conſidered further, that Bees, for two neceſſary reaſons, namely, the building of the cells, and the rearing of the Worms in them, attend, and of neceſſity muſt attend, the female, at all times and every where; for if ſhe has by chance depoſited her eggs in an imperfect cell, the reſt of the Bees are obliged, by virtue of their office as it were implanted by nature, immediately to make it complete, that the worm to be hatched may have room wherein to move itſelf, to eat, to change its skin, and to ſpin its thread: whenever therefore, which I would have obſerved particularly, the two females, each with her retinue, meet one another, and the Bees are hindered by it in their attendance and work, is it not eaſy to be imagined, there muſt ariſe a prodigious confuſion? where is the wonder then that they burn with fury, and, urged by love to their offspring, violently attack one another, determined upon killing and deſtroying one or the other female? This is falſely aſcribed by authors to the divided government of two fancied kings, as if they could not live together with a joint power; but this is an idle tale: all this fighting is cauſed ſolely by the propagation being hindered: take away this impediment, and the two females will live very amicably together; for as they have not the uſe of reaſon, they are unacquainted with Virgils maxim, that a kingdom does not admit of two rulers *;

"For two pretenders oft for empire ſtrive."
DRYDEN's Virg.

That this matter may the more eaſily be underſtood, I ſhall inſert here a rude kind of a ſimilitude. The republick of the Bees may be compared in ſome meaſure to a houſe compriſing five thouſand bed chambers, in which there is only one woman, who yearly by the ſcent of the ſperm in ſome hundreds of men born within this houſe, and living in it for the ſpace of ſome weeks, is impregnated with a triple brood. Suppoſe there were beſide in the ſame houſe ſome thouſands of natural eunuchs, or virgins, who, employing themſelves in the finiſhing of the chambers, and ſtaying in the paſſages between the ſaid bed-chambers, conſtantly attend that woman, that they may ſee in which chamber ſhe firſt brings forth a girl, a boy, or an eunuch; let theſe maids or eunuchs take care of and nouriſh this child that is born, as likewiſe all the reſt of them, which that ſingle woman afterwards in order, by going into each of the bed-chambers, is yet to be delivered of, and let the bed-chambers not be a whit larger than may be able juſt to contain the children, till they have arrived at their maturity. Theſe circumſtances being rightly underſtood, it is eaſily to be imagined what a horrid confuſion and diſcord would ariſe, were another woman likewiſe to get into this houſe, and the body of the eunuchs being divided into oppoſite parties, to fight againſt the former woman and her attendants, reſolutely ſtriving to lay yet another child in any of thoſe ſmall bed-chambers. Muſt not thus the ſettled order of the oeconomy be neceſſarily ſubverted? and muſt not all the inconveniencies and broils that can be imagined inevitably ariſe?

Behold! this is the true ſtate of the Bees government. It may be proper to take notice alſo of this ſingle particular, that in this houſe yearly by that one woman alone are brought forth three or four younger females, ſome hundreds of males, and ſome thouſands of eunuchs; and that then ſome thouſands of theſe new-born eunuchs and males together, join themſelves either to the elder female, or to the firſt-born of thoſe four younger ones, and having left their original houſe, they build a new one ſolely for their own habitation; but at laſt that theſe eunuchs kill all the males, as ſoon as the female, who came out with themſelves, is impregnated by the ſcent of their ſperm, and after that they live with the female alone for the ſpace of an entire year. If all theſe things are rightly applied to the republic of the Bees, it will be no longer difficult to aſſign a reaſon for every action of the Bees, whatever it be, ſuch as their building, raiſing their offspring, collecting of honey, and all the reſt.

From what has been here ſaid, it evidently appears, that one female, and only one, is neceſſary to, or can be ſuffered to ſubſiſt in one hive; therefore a hive that has no female in it, if it be provided with a due number of eggs, will continue in a better ſtate, than if two or more females dwelt in it; for in that caſe, one female innocently ſubverts and diſturbs the whole order, whilſt the other with her working Bees is labouring to perform the great buſineſs of producing and rearing the young, and building cells for them. I cannot but praiſe on this occaſion the wiſdom and circumſpection implanted in the Bees, that they on this occaſion always kill one of the females, but preſerve the other in ſafety; for without doubt it has appeared beſt to all-wiſe nature, that one female ſhould periſh, rather than that both of them, together with the hive, the eggs, the Worms, the Nymphs, and the reſt of the Bees, be involved in an univerſal ruin, ſince all this muſt neceſſarily be the conſequence of ſuch a diſturbance.

* Nothing is leſs underſtood in the hiſtory of the Bees, than thoſe battles we ſee often about the entrances of their hives. From what I have obſerved they appear to be of two kinds; ſometimes between the Bees of the ſame ſwarm; ſometimes between them and ſtrangers: any irregularity in their work may occaſion their ſcuffles with one another, and theſe terminate without miſchief. But in the other caſe, when ſtrange Bees attempt to force their way into the hive, the conflict is fatal, and there are uſually many killed; but the ſuperior number always gives the victory to the proper poſſeſſors of the hive.

But as nature, all-powerful in herfelf, is tied down by no laws, in other nefts of infects, and even in different fpecies of Bees, a different order and other regulations have place. This is manifeft in Hornets and Wafps; for thefe infects fuffer many females at once in the neft. It is proper to obferve here this remarkable difference, that each of thefe females lay only a few eggs, and that they fly abroad together with the males to catch lefs infects; with which, after the manner of fparrows, they feed their young; for of them only two kinds, namely the male and the female, live in one houfe: whether among thefe infects the male too, on account of getting food for the young, flies abroad, and fo is not, like the males among the Bees, exempted from labour, I have not hitherto obferved; though I make no doubt but that the male likewife contributes its help towards bringing up the young; for though Hornets are much fewer in number than Bees, they have fometimes no lefs than 1500 young to rear at once. In a Wafp's neft, which I keep by me, there are more numerous cells than thefe, and I found an infinite number as it were of young ones, eggs, and Nymphs in it. This male Hornet, like the male Bee, has no fting. From thefe examples it is manifeft, what wonders are difplayed to our eyes in infects, and with what ardency the fearching into them fhould influence us to magnify the glory of God: "For he doeth great things "paft finding out; yea, and wonders without "number." Job. ix.

That the office of rearing up the Worms, or the young brood of the Bees, is really intrufted to the common or working Bees alone, and that all their care, and every thing they do, is directed to that end, this fignal obfervation fhews plainly, which was communicated to me by a certain breeder of Bees yet living, who is thoroughly fkilled in the management of them. He told me, that by a certain and infallible method, a prodigious number of females, vulgarly called kings, might be procreated, and that from hence, in the fpace of one year, three or four times more fwarms might be obtained, than otherwife is ufual in our cold climate. It is done in this manner, viz. in the month of April, when on inverting a hive you fhall find fome eggs or Worms in the peculiar cells deftined for the females, take out the elder female, together with fome few Bees, and put them into another hive apart; thefe will fettle in this new place, build their cells, lay their eggs, and raife up a progeny: then fometime afterwards look again into the firft hive, and if you find there a female newly come our, fprung from the egg left before in the hive, take this likewife in the manner mentioned above, out from thence, and, in company with fome other Bees, put her into a hive of her own, that fhe may bring forth there. If in the fame manner you fhall manage afterwards the reft of the females, which fhall be one after another produced from the eggs depofited in the firft hive, in the fpace of one fruitful fummer, from a fingle hive, you will thus be able to get ten, nay, fometimes fourteen females, each together with a ftock of Bees, their fubjects as it were, that is fo many fwarms. It muft be obferved that this can only be done in a fruitful year, for at other times the Bees not only will not multiply faft enough, but they will not be able to provide a quantity of wax and honey to fubfift themfelves during the winter: care muft alfo be taken to prevent that firft hive from fwarming, fince each female, which with its working Bees is taken out from thence in the manner here mentioned, fhould be looked upon as conftituting a feparate fwarm. I fhall finally fubjoin this caution, that almoft all thefe hives will prove barren, unlefs males likewife are admitted into them at the fame time with the females. The breeder of Bees who told me this, did not know how, according to their received opinions of the Bees fitting on their eggs, to folve this difficulty; he allowed only this, that it might eafily happen, that fome of the Bees that are the fitters, for by this names the males are called, might fly over, from the firft, or the other neighbouring hives, to thofe before mentioned; for unlefs the females were impregnated by thefe, no generation, as I myfelf think alfo, could follow.

It appears evidently from this experiment, how induftrious the common working Bees are, and that they continue to perform their office, though the female be taken out of the hive; but if you carry off the brood from the hive immediately, they will give over their labours: fo long as they have the eggs or young ones, you will never fee the leaft appearance of confufion in the hive. Hence I demonftrate clearly what is the office of the working Bees; they, together with the female, have no other office: but to nourifh the young, and build little cells for them; whatever time they can fpare from this work, they employ in collecting honey and Bee-bread. Thefe common Bees are in truth kept in flavery, and appear to have been created by God to labour inceffantly.

In countries that are warmer and more fertile than ours, the Bees fwarm more frequently, without the artifice mentioned before. This is confirmed by the following incident, which a creditable breeder of Bees now living related to me as an abfolute fact, which had happened to himfelf. He told me, that when the count de Manfveldt about fixty years before had over-run the province of Embden, he had left him after that irruption one hive of Bees, from which the following year thirty fwarms iffued forth: that hive proved indeed extraordinary fruitful, after the reft of his hives, as well as thofe of his neighbours, were deftroyed, for on that occafion a vaft multitude of Bees had betaken themfelves to it. The firft fwarm from this hive he faw on Afcenfion day, and

and on the fame day, a little while afterwards, another fwarm alfo iffued forth; the firft of thefe two, after a month, fwarmed again twice, and the other fwarm that quitted the hive on the fame day, after fix weeks were paft, fwarmed three times. That fame year there iffued alfo, as well from the firft hive, the parent of all, as it were, and from the other hives he had obtained from it, three and twenty more fwarms, which with the former feven make thirty. It appears manifeftly from hence, that thefe infects are very prone to venery and extremely fruitful.

It is furprifing as well as pleafing to fee in what numbers, and with what affiduity, the Bees befet the mouth of the hive all around and without, when they are going to fwarm: the elder female, who is at this time impregnated for the year by the new-born males, often begins the fwarming. In the fecond fwarm, or when the Bees happen to fwarm for the third time, fometimes you may obferve two or three females at once, each of which we diftribute into peculiar hives, if there be a fufficient number of Bees for them, but we kill fome of them; if thefe are too few, the males for the moft part remain in the old hive, fince thefe, as I am fully perfuaded, have the moft convenient opportunity of impregnating the females. Sometimes, however, you will find males even in the late-formed hive of the new fwarm. This perhaps is the cafe when the female has not yet been impregnated, but that work is ftill to be done.

Bees may be hindered from fwarming, if all the males and females are taken out from the hive, and though there fhould by chance fome young female remain in the upper part of the hive, yet the whole fwarming will be ftopt, for this younger female continues barren. Whoever is defirous to extirpate from the hive in the manner mentioned the Worms and Nymphs of the males, muft go about it fo as by no means to cut away all the combs but thofe only which lie in the upper part, for thus the Nymphs and Worms of the males are lodged, and the Bees will be able then to carry out with activity the dead brood of males, and to cleanfe their combs again in a little time. Hence, indeed, this advantage arifes to the Bees, that they have nothing to do afterwards but folely to gather honey, becaufe there are already in the hive a fufficient number of cells prepared, which only want cleaning, and require but a little labour to repair them.

The fwarming being finifhed, when the Bees which have flown out have fettled and fixed themfelves upon the bough of a tree or fome fubftance, it is aftonifhing to fee in how fingular a manner, by the help of their legs, they ftick to one another, and form as it were a perfect bunch of grapes, hanging on one another by the affiftance of their claws. At that very time they can fly off from the bunch, and perch on it again; nay, even make their way out from the very middle of the clufter, and rufh into the open air, though they feem to ftick to one another fo extremely clofe.

Bees that have weathered out the winter, begin in the month of March following to lay their eggs in great abundance; from that time they continue this work inceffantly: firft, the female lays her eggs in the cells of the common Bees; next, in four or five or more particular cells, from whence the young females are to come; and laftly, fhe depofits the reft in the hotteft part of the fummer, or near the time of fwarming, into the cells of the males. If it fhould happen that there are not in the hive any of thefe cells made for the males, for fometimes they are cut away with the honey at the end of the year, then the common Bees, endued as it were with an unaccountable prefcience, build fome exprefsly for that purpofe; nay, thefe fame Bees nourifh the male brood in thefe cells with a care and affection no lefs than the hatred and fiercenefs with which they kill the faid very males, when, after the fwarming time is over, the female is impregnated by them. Nor, indeed, is it difficult for the Bees to kill thefe males, for they are not furnifhed with any weapon to defend themfelves, and befides they have wafted their ftrength in the act of generation, wherefore it is eafy to overpower them: indeed, they die otherwife naturally, for they are not fit either for collecting wax or honey for rearing up the brood, if they are not deftroyed before that time by the other Bees who have been their nurfes, and atone by a violent death for the pleafures they have enjoyed. Something fimilar to this is perhaps alfo the cafe among the Ants; for the males which are winged are found among the reft only at a certain time of the year.

To return from my digreffion; it is proper to take notice that the working Bees, when they have firft crept out of, or rather burft from their cells, are of a much paler colour and more inclining to dun than the old ones; thefe being browner and ornamented with a yellownefs not fo deep as gold. Their fting at that time has not come to its full ftrength: the bag that contains the poifon is as yet empty, from whence, if they are even then handled, they not only do not fting, but do not fo much as attempt it. After a very few days thefe young Bees acquire as ftrong a colour as the elder; nor do they ever, as fome idly fable, learn from the old ones the art of making wax and collecting honey: this is implanted in them by nature, and to perform it rightly they need no more than follow their own inftinct. The reafon why the Bees are paler at firft than afterwards is this, that thofe parts which are of a fubftance between horn and bone, in the head, breaft, and body, being but lately ftript of their fkin, have not yet in the new-born ftate their full hardnefs: their down is at that time more of a Moufe colour, but afterwards their parts gain both hardnefs and colour, when more of their fluids

fluids have evaporated thence, and the pores of the parts mentioned are contracted clofer.

Enough has been faid of the outward form, and of the generation, difpofition and actions of the Bees: I proceed next to the internal parts contained in the head, breaft and belly, which I fhall explain in the fame order that I obferved in treating of the Worm and Nymph. Thofe parts that are inclofed in the head and breaft, I fhall exprefsly treat of when I come to defcribe the male Bee. This only need be particularly obferved here, with regard to the head in common Bees, that their teeth or jaws are larger than in the others, and are furnifhed with two ftrong mufcles, the one larger, the other fmaller, which are indeed of a very firm conftruction, and take up great part of the fkull, which is of a fubftance between horn and bone. The tendons of thefe mufcles are cartilaginous, approaching to a fubftance between horn and bone, and being enclofed within the flefh, they there adhere on each fide in the manner that we fee the plumage on both ftick clofe to the quills in the feathers of Birds; but we may more properly compare this fabrick with thofe mufcles in Crabs and Lobfters, which move their claws; for in thofe the flefh in the fame manner is obferved to be joined with the great hard tendons of thofe mufcles; wherefore thefe fmall mufcles of the Bees agree with the mufcles of other animals in their ftructure, and are exactly fuch as the diftinguifhed Steno has defcribed them.

Since I have mentioned here the mutual fimilitude which there is between the mufcles of Bees and thofe of cruftaceous animals, I would have this further obferved, that, as in thofe animals the bony parts are placed on the outfide of the body and within, fo this obtains alfo after the fame manner in the Bee; and this ftructure is directly contrary to that which we obferve in larger animals and men, whofe flefh is placed outermoft, but the bones within, in the flefh, or between the flefh. However, the ftructure juft mentioned in the Bee, as alfo in Lobfters, does not conftantly obtain throughout, for in thofe places where the hard or horny bone, by which the joints of thefe animals are fupported, is to bend, or where the articulations are placed, thefe tendons, together with a part of the mufcles lie bare; fince, were it otherwife, there would arife from thence a great obftruction in moving. But again, all powerful nature does not ufe this method in all the articulations, as may be feen about the joinings of the horns; for in thefe, all that is mufcular is enclofed entirely within the cavity of the bony or horny matter; confequently the motion in thefe parts is obferved a little lefs diftinctly.

There remains another thing to be confidered even in the common Bee, I mean the trunk or probofcis, it being, like the teeth, much more remarkable in thefe than in the males. In this probofcis we are to obferve principally feven little parts; one of them, which is placed in the middle, Tab. XVII. fig. v. *i*, has no fellow, and is pervious like a hollow tube: this properly conftitutes the tongue or the trunk itfelf: the other fix little parts, difpofed in three pairs, furround the former on each fide, being deftined for affifting the trunk in the act of fuction, that it may be able with fo much the more eafe to draw out of flowers, and pour in by fuction, the natural honey found in flowers. In the trunk itfelf its divifions are to be confidered, which are extremely elegant and regular, and are befet all around with briftly, and as it were triangular hairs, diftributed in an elegant order. Some of thefe divifions at firft fight I took for articulations; there are above a hundred of them, and fome of them do not go through the whole thicknefs of the trunk. The ftructure of the trunk alfo, together with its mufcles, and the manner in which the fuction is performed, are very worthy to be obferved: but before I proceed to explain thefe, I fhall firft defcribe thofe three pair of little parts which are placed above and near the trunk.

The two firft little parts of the probofcis *a a*, are partly of a fubftance between horn and bone, and partly membranaceous: they are fet round with hairs, and are furnifhed with airpipes diftributed through the whole texture of them, though it be of a fubftance between horn and bone. Thefe tubes appear through it *bb*; the tips of them *c c* are a little bent, but where thefe parts are united with the root of the trunk *d d*, there they have a kind of an appearance of an articulation, by the help of which they may be bent,; near the trunk and the reft of its parts, quite within, and as it were under the chin of the Bee, if I may fo fpeak, I reprefent them in this draught drawn a little outwards and fideways, but the natural fituation of them is juft as Tab. XXV. fig. IX. under the letters *f f* in the Nymph fhews. The ufe of thefe feveral parts is to contribute their affiftance towards the moving of the trunk downwards, and underneath againft the head, and a little towards the breaft, as well as to affift in clofing and confining it, together with the other four, or rather the two pair of little parts; and alfo towards defending, covering, and guarding it from injuries. I fhould think that they alfo affifted towards fwallowing the native honey, drawn up by fuction when the trunk is filled with it, or thrufting it further inwards towards the ftomach, fince they have power to fqueeze the fnout below and inwards ftrongly enough.

The two other little parts of the trunk, Tab. XVII. fig. v. *e e*, which figure IX. of Tab. XXV. reprefenting the Nymph, fhews in their natural fituation under the letters *g g*, are placed a little higher than the firft pair, but they are nearly of the fame ftructure. There is, however, this remarkable difference, that each of them has in the upper part, at their extremities, three joints, one, Tab. XVII. fig. v. *f f*, lower and longer, and the two others *g g* higher and fomething fhorter, which are all furrounded with

with fine hairs. Thefe little articulated parts do not, like the former, embrace or cover the trunk, but are only placed near it on each fide, and, where they rife up about the root of the trunk, they are alfo articulated. As to the ufe of this pair, I am entirely of this opinion, and without any hefitation conclude that they are of very great affiftance to the trunk in the act of fucking; fince they as it were in the manner of two fingers affift the trunk, open the leaves of the flowers, and remove whatever elfe might chance to obftruct it: therefore I compare thefe two little parts to the two fore feet of a Mole, by the help of which it pufhes the earth from the fides both ways, that it may be able with its fharp trunk to fearch for its food the more conveniently. The two laft little parts *h h* are much lefs than the firft and fecond, and are of a texture a little partaking of horn and bone, but rather membranaceous, and they are rough likewife with hairs: thefe, together with the trunk itfelf, are drawn inwards, and, as I myfelf think, the little articulated parts are affifted by them in their operations, fince they remove themfelves a little from the fides of the trunk, and may very happily affift to pufh afide the leaves of the flowers. Even by their motion they feem as if they were contrived to help alfo towards carrying the honey upwards, and preffing it towards the ftomach.

The ftructure of the trunk *i* is partly membranaceous, and partly of a fubftance between horn and bone, or griftly; but its hairy skin, full of cuts, muft be confidered particularly. Here, before I proceed any further, it is neceffary I fhould mention firft, that I fhall defcribe and reprefent the trunk here in the under part, as it fhews itfelf in the Bee when laid flat on its back. As to what regards that part of the trunk *k k* which is of a fubftance between horn and bone, it is formed in fuch a manner, that it can fly off from the reft of the trunk arch-ways, and fpread itfelf in the fhape of a circle, Tab. XVII. fig. VI. *b*; from whence it is that the membranaceous part *c c c c*, which lie moft beautifully folded up under the griftly part, fig. v. *k k*, and joined with it, may be confiderably expanded on each fide like a fail, in the middle of which a maft is fixed. This mechanifm, however, does not fhew itfelf plainly, unlefs we circumfpectly and nicely, with a very fine-pointed needle, raife that horny bone a little up: in that cafe it is at length feen how the membranaceous part of the trunk is folded, and how it expands itfelf; fo that the internal cavity of the trunk *i* is prodigioufly enlarged and widened, infomuch that a very great quantity of native and undigefted honey, in proportion to the fize of the infect, may be received into the trunk. Indeed, nearly the fame courfe of nature is feen here, that we obferve in Monkies, which can hide nuts and what other fruits they have gathered, in two membranous bags, which are placed on each fide of their jaws: fomething like this obtains alfo in fome kinds of Birds, which in the membranaceous and expanded part of their bill, where the beginning of the ftomach is inferted, preferve a Fifh they have catched. Amongft other water-fowls this is moft obvioufly feen in that fort of Cormorants, which in our way of fpeaking we call Schoffers. Thefe birds once every year frequent the foreft of Sevenhufen, not far diftant from Leyden, and are fhook down from the trees in great numbers, and as foon as they fall into the water they are able to fwim immediately, and to dive quickly under water, though they have never before either flown or fwam. In the fame manner Bees alfo have implanted in them the art of making wax, and gathering honey in their probofcis or trunk.

Before I proceed further in the defcription of the trunk, I fhall infert an account of the manner of their catching fifh in fome parts of Europe, by means of the juft mentioned fort of Cormorants: fome few years ago many of thefe birds were carried to England and fold for that purpofe. In the firft place then they make them tame, fo that they may be brought to perch and ftay upon the hand of their own accord: when after this they are inclined to go out a fifhing with them, they tie to one of their legs a thin but ftrong cord, which they keep rolled up in a ball: afterwards they hold this ball, which is wound round a little fteel pin, by a wooden handle, as our girls do their bobbins, while they roll off of them the threads made on the reel: thefe things being prepared, they put a ring round the Cormorant's neck, and being now come to the fifh-pond, they let the Cormorant fly down into the water; then the cord is rolled off of the ball with a whizzing twirl, and the Cormorant, to the great amazement of the fpectators, quickly feizes fome fifhes: thefe, however, are ftopt at the ring that has been put about its neck: therefore when the Cormorant is afterwards drawn out by the cord, he may eafily be made to throw out again the fifhes it had taken into the mouth, only by fqueezing its ftomach and throat upwards. A perfon of great credit and ingenuity told me this ftory, who has himfelf fometimes feen this manner of fifhing. When I was in company with Mr. John Oort, an old friend of mine at Honflaardik, I obferved with aftonifhment that certain water-fowls there, when any fifhes were given them, would always turn them expeditioufly, fo that they could take them in head foremoft: this was done through great caution in them, that they might not be hurt by the fins of the Fifhes, as they went down their throat. Whatever we could do to make thefe fowls fwallow a fifh tail foremoft, they could not be brought to it; for they always ufed, by the help of their beaks, dexteroufly to turn the fifh over. To return to the trunk of the Bee; it is to be be obferved, that the membranaceous part of the trunk has no hair on it, but in its place is covered all over with little protuberant pimples; thefe are tranfparent, and are placed there in regular order, and at equal diftances from each other, and in fome degree refemble the little rifings obfervable on the skin of birds when their feathers have been plucked off: thefe little parts feem to be in reality glandules, which have perhaps a power confiderably to change the honey that is fwallowed down, and in fome meafure to forward the connection of it. This alfo is to be obferved in regard to the ftructure of the griftly parts of the trunk, or that which is of a fubftance between horn and bone, that in the middle it feems to approach nearer to the nature of an horny bone, than it does at the fides, which are of a little deeper or dusky red colour. This part of a fubftance between horn and bone, Tab. XVII. fig. v. *k k*, does not every where retire outwards from the trunk; for a little below the orifice or mouth of the trunk, it tends inwards *n n*, and, uniting with the other hairy part of the trunk in a narrower and thinner canal as it were, is then carried altogether inwards and forwards *o o*. But in the fame place the whole trunk in its circumference is then crowded with fmall hairs, like little claws a very little bent, which, whether they are open canals, or ferve by way of little claws or hooks, to keep the trunk during the time of fucking in its fituation and place, I will not determine; for as yet I have not fo clearly difcovered how it is, though I make no doubt but it may be found by time and application. That portion of the trunk which is of a fubftance between horn and bone, at the end of that part where it verges outwards, has a globule or little head, which appears very remarkable; and in the middle of this an opening is feen, which feems to me to penetrate quite into the cavity of the membranaceous portion of the trunk; neverthelefs I now find this opening is not, as I have before faid, fo fmall as the apertures of the lacteals, though under a microfcope it may appear fo: indeed the beginning of it in this place, in proportion to the part, is fo minute and narrow, that fcarce any thing certain can be advanced about it to clear up all doubts. In Butterflies I am confident that the trunk opens with many lips, which imbibing the nourifhment, appear at the end of the trunk like fo many little hairs: but in the Bee a different ftructure is obferved; that little part or diminutive head of the trunk, Tab. XVII. fig. v. *o o*, together with its little membrane, in which the hairs are fixed, is able to contract itfelf into a narrower compafs, and likewife to move itfelf inwards, as is manifeft if this part be touched and examined at different times, and efpecially if it be carefully examined in the younger Bees, and then in the more perfect. I have reprefented this in the form wherein I can fhew it at any time. Further, this portion of a fubftance between horn and bone, at the lower part fpreads into two legs as it were *p*, which are connected with the other lower portion of the trunk: where this connexion is made, there are difcovered three more little parts of a fubftance between horn and bone *q q q*, perfectly black like pitch, fhining, and joined to one another by feveral articulations. The middlemoft of thefe is the fheath as it were of the trunk, within which it at that time, when it is not employed in fucking, by the help of fome mufcles, is drawn back and concealed; at the fame time alfo the other little parts likewife of the trunk bend themfelves, and retire inwards. In this fheath of the trunk thofe mufcles alfo are enclofed, which belong to the two pair of the articulated little parts of the trunk *e e*. The mufcles next of the firft pair of thefe little parts, Tab. XVII. fig. v. *a a*, are placed a little lower, and are implanted with two horny little parts *q q* towards the outfide, of a blackifh colour: but the two little parts themfelves, together with the fheath of the trunk, are joined by four diftinct articulations *r r r r*, to the extremities of the bony or horny parts, which together conftitute the head of the Bee: fo that the whole fheath, the trunk, and its little parts, are, by the help of two ftrong mufcles *f f* moved inwards at once; on which occafion the parts juft defcribed bend themfelves backwards and inwards, and at the fame time hide, cover, and fhut in the fheath. Thefe beforementioned mufcles *f f* here appear through a little thin membrane *t*, and under this the throat *l* alfo is feen, which, together with thefe mufcles, and the membrane covering them, is cut through in this figure.

We come now to the act of fuction, which the Bee performs in the following manner; it gradually draws the griftly part of its trunk, or that which is of a fubftance between horn and bone *k k* from the hairy skin and its divifions, which done, the membranaceous and wrinkled part of the trunk *m* is ftretched out and made fmooth, but the griftly part is diftended arch-ways: when this is performed by the help of the mufcles of the trunk, the ambient air is neceffarily forced out of its place, and by the preffion of it the honey is carried inwards, and through the cavity of the trunk.

In Butterflies, on the contrary, this is performed in quite a different manner; for as much as in thefe the trunk is not fingle, as in the Bee, but double; which alfo, after the fuction is ended, is wonderfully curled and rolled up together, by numberlefs moft minute articulations; fo that Butterflies muft execute their fuction in a quite different method, namely, by pinching clofe the points of refpiration, and fwelling out their body, they repel the air, and this being driven out, pufhes forward into their trunk the fweet moifture for which they gape in fucking. The doing this

this is very eafy to the Butterfly, fo that I fhould think even the Bee too, while it is fucking, does the fame thing, for what hinders, but that this or fomething fimilar may be performed by the Bees, fince their points of refpiration, though membranaceous within, have a horny edge, by the force of which they can open themfelves into an oblong flit, and clofe themfelves again, in like manner as the Frog ftretches out and fhuts again the upper part of its wind-pipe, as the moft renowned Malpighius has obferved with the utmoft exactnefs? I might now defcribe all the mufcles of this part, one by one, and reprefent them in figures; but that would involve me in a work requiring both a vaft length of time and endlefs labour : this is the reafon alfo that has hindered me from purfuing many other particulars, which I have here delivered to the utmoft, and with the ftricteft accuracy.

Should any one now afk me, whether the Bee can fuck no other way, than by ftretching out or moving arch-ways the little griftly part of its trunk, I anfwer, that it entirely appears to me, that even by barely pinching clofe their points of refpiration, and fwelling out their body, the Bees may be able to perform their fuction; for nothing hinders, but that even by thefe means alone the air that is driven out may pufh the honey inwards. We obferve alfo that the Bee, when going to fuck in the air in its little pulmonary tubes, moves the rings of the belly within and without, in the fame manner as we do our breafts in the act of breathing; but becaufe the thorax in Bees is immoveable, therefore their belly performs this office. This little part, which has been now defcribed, is worthy of the higheft notice; nor can I here forbear owning, to the glory of the immenfe and incomprehenfible Architect, that I have but very imperfectly and fuperficially attempted to defcribe and reprefent this little part; for to reprefent it to the life, in its full perfection, as truly moft perfect it is, far exceeds the utmoft efforts of human knowledge: and in very truth, our intellects and abilities fail us every where, when we venture even no further than to contemplate the divine wifdom in the works of God, which can never be worthily magnified. Think then how much more excellent they muft have been before they became obnoxious to deftruction! in reality, this fingle little part is formed with fuch exquifite fkill, that it may juftly be ranked among the chief inftances of the omnipotence of the Deity. But I would have this underftood according to the narrow limits within which our capacities are confined, for we fee the works of God only as through a glafs darkly, fince our underftanding refembles an ignis fatuus, a Will-with-a-wifp, and is utterly unfit for difcerning thefe things, which fo furpafs all mortal comprehenfion.

In other forts of winged infects approaching to Bees, for example in the Wafp, the trunk is much flenderer, nor is it of fo remarkable a length; the reafon of which difference feems to me to be this, that in thefe infects, befides the trunk, there is another way ftill by which they can draw in their food, fince they are little creatures of a very rapacious, favage, and greedy nature. This is efpecially manifeft in that larger kind, which we call Hornets, which are rapacious to fuch an amazing degree, that even when cut through the middle of their body, they do not refufe to eat; and if then you give them honey, or fugar moiftened with water, which is much the moft proper, they fuck it in fo greedily, that you may fee it again running out at the wounded part. I have confidered the trunk in the largeft fort of Wafps, a draught of which, for its great elegance and particularity, I fhall give in this place.

A delineation of the trunk or fnout of the Wafp, as feen from underneath.

Tab. XVII. Fig. vii.

a Is a part of the horny fubftance at the bottom of the head; it is fhagged at the fides with yellow hairs, is marked alfo with two yellow fpots, but for the reft it is black, and fhining.

b b c Are three little horny parts, at the root of the trunk; thefe are of a fhining black, and two of them that are at the fide *b b* contain in them thofe mufcles, which move the articulated briftles *d d*; but the little horny part in the middle *c* is, as it were, the fheath of the trunk itfelf *f*, in which, befides the mufcles of that organ, thofe of the other two articulated briftles *d d* alfo are depofited.

d d d d Are four articulated briftles, that affift the trunk during its action.

e e Is the place where the teeth have been broken off.

f Marks out the trunk itfelf, in which are feen four delicate white little parts, furnifhed toward their tops with round and yellow globules. All the parts hitherto mentioned are covered over with hairs, which indeed I have not exhibited here with them, left it fhould create confufion. It is to be obferved alfo, that all thefe parts are reprefented as in the Wafp laid along on its back, from whence it is, that we can fee but half of fome of them.

If a Bee is opened on the back, there firft prefents itfelf a limpid or clear humour iffuing from the veins and the heart, which are wounded; for the heart is placed oblong in the back, as it is in the Coffus, Silk-worms, and many other infects.

The mufcular fibres alfo are feen, which move the rings or incifions of the body of the Bee, and are the fame both in fituation and

ftructure,

ftructure, as I have fhewn them in the Coffus.

The fat alfo appears, confifting of little round parts, which have been fixed to their membrane.

The lungs are more than all other parts remarkable; thefe are two white and tranfparent little veffels, fig. IX. *a a*, confifting of the pulmonary tubes dilated, and running together. Thefe lungs are entirely membranous, and fall together when the air is out of them, which is by no means the cafe with the tubes that proceed from them, inafmuch as they, confifting of rings curled around, remain always open. The lungs, compofed as I have obferved of dilated ramifications of the wind-pipe, terminate again in little tubes, Tab. XVII. fig. IX. *b b*, which are annular; and thefe, then here and there widening, grow into little bladders *c c*, and thefe alfo contract themfelves again into little tubes *d d*. This alternate mixture of bladders and tubes, however, is not fo frequent in the Bee, as in the Rhinoceros Beetle, whofe lungs confift of numberlefs little bladders, which may in fome meafure be compared to the pods of the plant called Honefty, while yet hanging from their ftalks. In Bees the lungs are principally compofed of two large bladders; there are likewife befide them fome fmaller, and the remaining part is made up of little tubes, which then, as in the Worm of the Beetle, or as in the Worm of the Bee itfelf, are difperfed over all parts of the body *e e*, &c. fo that the lungs, by the intervention of the little tubes which they fend out, communicate every where with themfelves by mutual inofculations *f f*.

When a Bee is opened along the belly, immediately the fpinal marrow comes in view, and this I am now going to defcribe: nor fhall I here ftop to mention either thofe parts which are feen in this view befides, and have been mentioned before, or the extremities of the rings, which are membranaceous and terminated by black edges of a fubftance between horn and bone. The fpinal marrow is the principal part, which now prefents itfelf to be confidered; it confifts, as in the Silk-worm, of nerves and little knots, which owe their rife to two nerves as it were proceeding from the brain, though there feems to me to be befides thefe fome fubftance of a different nature from them in the fame place, which, for the fake of ftrengthening them, binds the little knot and the nerves together: this is feen alfo in Silk-worms; nay, and in the human fpecies, thefe nerves, which are fwallowed up as it were in little knots, are feparated from one another here at a more confiderable diftance, and open much wider afunder, than in the marrow of Silk-worms; indeed, the marrow in Bees is almoft every where open or fplit into two parts, while in Silk-worms it opens only at diftances. What are diftinctly called the nerves by anatomifts, are thofe fhoots which arife from the fides of thefe little knots. If we trace the courfe of the marrow near the lower rings of the belly, there the nerves, fpringing from the little knots, are feen, and they difperfe themfelves among the mufcles defigned for drawing the fting inwards and thrufting it out. The other vifcera moft confpicuous in this view, are the ftomach, the guts, and fome parts belonging to the fting.

The ftomach, the gullet leading to which is moft exceffively narrow, feems to me membranaceous and thin, though it has fome flefhy fibres. It is often filled with honey, which is eafily diftinguifhed by the tafte; the pylorus follows the ftomach, and after this comes in view another little part, fomewhat more protuberant, and inclining to a colour between yellow and red, which however, when more accurately infpected, proves to be only fomething fhut up within the hollow of the inteftine, and fhining through in that place.

Next follows an inteftine, which in fome meafure refembles the colon in other animals: this gut is much thicker than the ftomach itfelf, efpecially when it is full; it has moreover ftrong mufcular fibres, which, when they act, turn it up in many wrinkles and folds; its cavity is commonly full of a whitifh matter, which feems to me to refemble the white of an egg that has been fteeped for fome time in rectified fpirit of wine, and is juft beginning to curdle; or it is like ftarch mixt with a fmall quantity of water. If this little gut is pricked with the point of a lancet, the matter juft mentioned flows out.

Further down this gut is confiderably contracted and made fmaller: but there, where this contraction begins, an infinite number of whitifh filaments are feen, like thofe which in the Coffus I have called faffron-coloured veffels. Thefe filaments or minute inteftines are faftened to the gut, in that part where it is contracted, as well as elfewhere. This clofe connexion of them with the gut is extremely ftrong, and is effected by means of the pulmonary tubes, which, as they run through the whole body, fo in this place particularly they are an infuperable obftacle to the difengaging thefe little guts. I believe it would take me up fome months to fearch this matter thoroughly to the bottom, which truly feems to be by no means defpicable, nor unworthy that fo much pains fhould be employed upon it, as I fhall hereafter fhew.

The gut, after it has been contracted in the manner already mentioned, dilates again on a fudden, though here it feems to be altogether membranous; but as it is at the fame time tranfparent, fome little, whitifh, and oblong parts are feen on the outfide, as fhining through it: thefe, when the gut is opened, are found to be fix in number, and are glandular, and they are not every where uniformly whitifh, but are filled with watery and tranfparent qualities. Thefe fix little glandular parts fwell out very confiderably on the inner furface of the gut, within its hollow, and are there very confpicuous

cuous. I have alfo perceived little parts of the fame kind in the inteftines of Hornets. It is obfervable befides, that the extreme part of the inteftine, in which thefe fix little parts are found, is fometimes fwelled, almoft beyond what could be believed, with excrements. Thefe are of a pale yellow colour, and are divided into fmall pieces, like bee-bread, though their little lumps are neither round, nor of any other regular figure. One may further remark, that the inteftine, in which thefe fix oblong glandular little parts are placed, is fometimes found as fully diftended with an aqueous humour, of a yellowifh colour, as with the yellow and more folid matter beforementioned. But this is only in very young Bees juft produced from the Nymph.

This gut is again contracted where it ends, but from that part it again dilates itfelf, and at length forms the rectum or laft gut. This extreme part of the inteftine fometimes wants the laft contraction, and in that cafe appears rather like rumpled linen, or a cotton handkerchief, drawn through one's hand. The inteftine finally terminates under the point of the fting where the excrements are voided, and the rectum arifes from it.

If thefe guts joined to the ftomach are laid on a thin plate of glafs, and heated by the flame of a lamp till thoroughly dried, then you may fee not only their circular fibres, but even thofe valves which have been called by Kerkring in the inteftines of men, the valvulæ conniventes, and which were defcribed and in fome manner delineated by Spigelius. Ruyfch firft, in the year 1667, demonftrated them in an inflated human gut. I have made the fame obfervation alfo in the Bee and Wafp.

Behold! thefe are the entrails of the common or working Bee; there does not appear among them the fmalleft trace of fpermatic organs or the genital parts, or of any thing which can anfwer the purpofe of, or even be compared to a penis or ovary. Hence I think thefe Bees may moft juftly and properly be faid to be natural eunuchs, and fuch as can only work and feed, cherifh and rear the progeny of others as their own. On the contrary, as I have beforementioned, the genital organs are very plainly feen in drones, as they are the true males of the Bees: their whole belly is in a manner filled by the tefticles, as I fhewed to his ferene highnefs the grand duke of Tufcany, among other wonders of nature, in the year 1668, when he gracioufly condefcended to approve of my labours.

I fhall now proceed to the fting, that wonderful work of nature, and eminent example of the wifdom of the great Creator. It is placed in the hinder part of the body, its point lies juft over the end of the rectum or ftraight gut: the fting is therefore placed in the laft rings of the belly, with which it is alfo very remarkably jointed, by means of fome cartilages. But as the fting is worthy of the greateft attention, I fhall defcribe it at large, together with all the parts fubfervient to it, having in view only the praife and glory of the moft wife and excellent Creator. In the fting there are difcovered, firft, the channels through which its poifon is conveyed to it: Secondly, its cartilages. Thirdly, its mufcles. Fourthly, its two pieces called legs. And laftly, the fheath within which the legs which properly conftitute the fting are hid.

That the fting has poifon in it, R. Hooke, a writer of great experience and learning, has in fome meafure laboured to demonftrate in his ineftimable micrographia, written in Englifh, thinking that the poifon lay hid in the hollow thicknefs of the fheath of the fting, which however is never the cafe, unlefs by mere accident.

Let any one with a forceps or little fteel tweezers take hold of the legs, wings, or which laft will be moft convenient, the breaft of the common Bee, and he will generally fee a fmall clear drop as it were of water hanging on the point of the fting. In this water the poifonous quality of the Honey-Bee is properly contained. This, as foon as it drops into the wound, produces the pain that follows the wound; for the fting itfelf is not in the leaft degree venomous, nor does its puncture hurt more than that of a needle. For experiment's fake I have often wounded myfelf with the fting, and felt no other ill confequence from it than a flight itching in the wounded part; but the fting muft be firft thoroughly cleanfed and well fqueezed and wiped for this trial, for it might otherwife probably happen that the injury would be more confiderable.

To proceed in order, I would have it obferved, that the venomous liquor which only paffes through the fting is originally depofited in the belly of the Bee, and there contained in a little bladder nearly tranfparent. This little bladder is of an oblong figure, and of a very ftrong texture, fo as to bear the force of the fingers preffing it without any damage: nay, fo great is its firmnefs, that the belly of the common Bee being opened, let this little bladder be taken hold of, and the whole fting and all its parts may be eafily drawn with it out of the body, without the bladder being broke. I have found this bladder of poifon fo ftrong, even in the fmaller kinds of Wafps, that by preffing it with my fingers as hard as I could, the poifon might be thrown to the diftance of two foot from it through the fting. It is further remarkable, that a very ftrong mufcle twines about this little bladder, and has its tendril in the middle, as it is in the mufcle called the temporal mufcle in the human fpecies. When that mufcle contracts itfelf, the poifon is by its force fqueezed out and thrown into the wound, fo that the fting may be compared to a fmall fyringe; the little bladder or rather the mufcle of it juft mentioned ferving it in the ftead of an impelling plug. But I have not hitherto diftinctly examined this mufcle in the common Bee: I have feen it in the Wafp,

 and

and moſt conſpicuouſly in the Hornet, after I had firſt kept that inſect a whole year in balſam. This method I ſome years ſince diſcovered, and by it the parts may be moſt happily and diſtinctly viewed. There comes out of this little bladder, in every ſpecies of Bees, a ſmall thin tube, which is extended as far as the ſheath of the ſting, and this at length runs between the two open legs of the ſting, enters into the ſheath, and terminates in the thickeſt part of it. It is by this channel that the poiſon is conveyed from the little bladder through the ſheath into the ſting, and paſſing from the hollow part of the ſheath between and under the legs of the ſting, it is darted into the wound when the Bee gives the ſtroke.

On one ſide of the little poiſon-bladder in the Bee, is ſeen a ſmall, oblong, thin, crooked tube. Of this kind I have obſerved two in the Hornet, in which creature the poiſon-bladder is alſo twice as large as in Bees. I have ſeen beſides other ſmall tubes growing laterally out of that I mentioned, but I could not immediately diſcover whether they terminated. I afterwards however obſerved in Waſps and Hornets, that in the body of theſe animals there are two diſtinct little tubes, Tab. XVIII. fig. IV. *c c*, inſerted into the hinder part of the poiſon-bladder *a*, through which little pipes the poiſon is conveyed into that bladder, and in which the poiſon is properly ſecreted. Theſe ſmall pipes appeared unequal, with little ſwellings here and there, as is ſeen *d d d*, and terminated in cloſed endings *e e*, as the blind guts of Hens, which ſame thing I have obſerved alſo in Bees. Theſe ſmall veſſels are much wider towards the hinder parts than in the fore parts, and about their extremities where they are cloſed, they are very thickly ſurrounded with fat and pulmonary tubes, for which reaſon they cannot be ſeparated from the other parts without great difficulty. I have alſo remarked, that theſe poiſonous veſſels in Bees very nearly reſemble thoſe which are found in Waſps, and are juſt ſuch as I have in the third figure, Tab. XIX. *z*, drawn to the life in a female Bee: *z* denotes the poiſon-bladder in the female; *γ* the ſluice of the bladder; *α* the ſmall tube in which the poiſon or venom is ſecreted, *β β* are the cloſed ends, the ſmall tube in which the poiſon is concocted. Theſe appear to conſiſt of a two-fold ſubſtance; the one glandulous, of a whitiſh colour, and not of a very firm texture; the other is membranaceous, with ſomething like a filament quite tranſparent, which ſticks within the former ſubſtance, by which it is ſhut in and ſurrounded, like the ſmall tube of the veſſel called the vas deferens, which is in itſelf extremely ſlender, and is alſo compaſſed about by a glandulous and nervous ſubſtance. The former ſubſtance is very eaſily ſeparated in the handling of it from that within, which is ſkinny, tranſparent, hollow, and very much like a fine hair. This ſmall tube is beſides very ſtrongly joined to the ſaffron-coloured veſſels by numerous pulmonary tubes, ſo that at firſt ſight I ſhould have thought theſe veſſels were productions of the ſmall tube; but as they are moſt ſtrongly fixed to that part where the gut contracts itſelf, and the ſubſtance they conſiſt of curdled in my balſam; whereas, on the contrary, the humour contained in the ſmall pipe of the poiſon-bladder remained clear and bright in the ſame balſam, I was thoroughly convinced from thence, and from what I have before mentioned, that this ſmall tube has no communication with the ſaffron-coloured veſſels.

When the poiſon-bladder is put into my balſam, it is ſometimes tinged with a purple-colour or redneſs. I likewiſe have ſeen it green, in the Hornet. And we muſt further obſerve, that the poiſon-bladder in Bees, as I have often obſerved, is not contracted in a globular form, like the urinary bladder in the human ſpecies: ſo far from it, that its ſides are like two planes preſſed together. This may be ſeen if you cut off the Bee's wings, and then greatly irritate or provoke the creature; for then it will, in revenge, throw its poiſon out of the ſting, being every moment eager to ſtrike and wound.

Let us proceed. The ſting then, as I have ſhewn, is ſituated under the rings of the poſternal parts of the body, and is there moved in and out by the help of certain muſcles; and as theſe muſcles are affixed to ſome horny or bony little parts, I ſhall therefore briefly deſcribe theſe parts. There are chiefly ſix principal little parts, together with two others leſs conſpicuous. The legs or ſhanks of the ſting are articulated with theſe horny or bony little parts, which are likewiſe joined with each other, ſo that by means of this ſtructure they may be moved in and out, and up and down, and on either ſide. This motion is performed by the force of the muſcular parts, which I find to be eight in number, four very manifeſt, but the reſt leſs conſpicuous. The horny or bony parts, and even the ſhanks of the ſting, are inſerted in all theſe muſcles. Two of the muſcles, which are ſomewhat leſs conſpicuous, encompaſs or ſurround that ſide of the ſting which is the thickeſt, being connected with the caſe or ſheath. There is likewiſe a ſmall horny or bony part there, conſtructed or formed in the ſame manner as the little bone in Birds, called the perſpicillum, which is properly produced or originated from the collar-bones concreted together. This little part is particularly articulated, and by the help of its muſcles ſeems to move the ſheath or caſe of the ſting regularly outward.

I ſhall now deſcribe the ſhanks of the ſting, and ſhew that it is not a ſimple but compound part; that it conſiſts of two ſhanks, and a ſheath wherein the ſhanks are kept, like two ſwords in one ſcabbard. Theſe ſhanks of the ſting are not conſtructed in the manner of the crura of the penis or clitoris, which ariſe each from a diſtinct place, and at length meet and conſtitute one body; for the ſhanks of the ſting continue all the way diſtinct from each other, though

though their points be fo near to each other, that the intermediate fpace can fcarce be obferved, and no body thinks he fees any thing but one point. Each of thefe fhanks is furrowed on one fide, but on the other it is ftrengthened by certain hooks: hence, whilft the equal fides and points of both fhanks are joined together, the fting is provided from each fide armed with hooks. But, in order to underftand this matter juftly, one muft know the ftructure of the fheath of the fting; and therefore I would have it obferved, that this cafe or fheath is not in reality difpofed in fuch a manner as the fcabbard of a fword or knife, or like the cafe of a rocket: by no means, for the fword, knife, or other weapon are on each fide hidden in their fcabbards, and furrounded or covered entirely by them, nor is the cafe of the fting made like the fmall open tube or canula, through which furgeons pafs their inftruments, when they are to cut a particular part in fuch a manner as that the adjacent parts may remain unhurt. The cafe of the aculeus is more like the horn-book made in our country for children, or one of thofe cafes, the verge of which is furrowed and receives a moveable cover. The fheath is formed nearly in this manner: its inner fide each way is prominent, or has a rifing back, or it is fomewhat bent with a double margin; but thefe backs, like bolts, agree with and are joined to the furrows of the fhanks of the fting, and therefore thefe fhanks are very eafily and conveniently moveable up and down, like the operculum or cover in the furrow of the cafes juft named. But the fting itfelf is fituated in fuch a manner in this fheath, that its points lie as it were in the open cavity, but the crooked hooks fhew themfelves out of the fheath's cavity; except when the fting appears beyond the extreme verge of the fheath, and is confequently thruft out: therefore, the lower fide of the fhanks of the aculeus or fting lies always in the cavity of the fheath, and the upper fide is out of it. Thefe fides of the fhanks have crooked hooks, hang out of the cafe, and receiving in their furrows the internal ribs and prominences of the fheath, they are moved eafily along the latter; whilft, in the mean time, their upper fides being fmooth, are applied to each other, and with their united extremities they form the point of the fting.

Further, it is proper to obferve that one of the fides of the cafe or fheath is not open through its whole length, nor does it refemble the inftrument before named, equally extended without its valve: it is rather on the hinder part, where it is broadeft, and united together, under which part the fhanks afterwards pafs. This is very particularly and plainly obferved in the fting of the Hornet, in which the fheath entirely coalefces in the hinder part where it is thickeft. But in Bees thefe minute and narrow paffages are no where entirely united; therefore the fheath in that place embraces the fhanks of the fting, at leaft in part, by that means preventing thofe fhanks from moving out of their places, as may be feen, Tab. XVIII. fig. III. unders the letters *d d*.

Each fhank of the fting has ufually ten crooked hooks near its point, and fome others which are lefs remarkable: but the fheath or cafe has no hook at all; becaufe if it had, the fting itfelf could not move backward and forward in it. Since therefore each fhank has ten hooks, the fting, when the Bee has given its ftroke, is kept in the wound, being fixed there by twenty bearded hooks; and the more the Bee endeavours to draw the fting out, the deeper its hooks penetrate into the wounded part. But if the fting be taken out of the body of the Bee, together with the inteftines and other parts, as I have mentioned, it may notwithftanding then infinuate itfelf more and more deeply into the wound, being in this refpect like the heads of vipers, which will bite after they are cut off. This we are clearly taught by experience, fince we fee that when the fting is drawn out of the body of the Bee, it penetrates ftill deeper into the wound, trembling, and as it were fhaking in all its parts. The reafon of this is evident, for the fting is thrown out together with its fheath, and all the cartilages and mufcles belonging to it, together with the poifon bladder. I have often made the before-mentioned experiment in tan-leather gloves. The Bee muft firft be fuffered to fix its fting in them, and then it muft be taken by the wings and pulled away forcibly, fo that the fting may be drawn out of the body. One may fee that the fting penetrates deeper and deeper into the leather: nor indeed is there any thing to hinder the doing of this, fince the fting confifts of the two fhanks before defcribed; which, as their tops or ends are united together, fo both and each of them feparately may be moved: therefore, whilft one fhank is fixed in the wound, the other may be thruft further and deeper; and where this latter lies firm by means of its crooked hooks, the former, on the contrary, may be infinuated deeper into the wound, or thruft into it deeper than the former. By this means the fting and its fheath penetrate further into the wound. Therefore it frequently happens, that the fhank of the fting is drawn further back into the cafe, and the other thruft out of it in proportion. Thus when the Bee hath ftruck the glove, and the fting is then taken out of it, it is frequently found that one fhank appears further ftretched out of the cafe than the other; that is, the two fhanks of the fting have been then unequally fixed, and one is ftruck in more deeply than the other, and fixed there by means of its crooked hooks. When the fting with its appendages has been juft pulled out of the Bee, if it be lightly put into any callous part of our skin, the fame confequence naturally fhews itfelf: for it is then plainly obferved, that the fting penetrates every moment deeper and deeper into the wound; but however it does no harm, provided the callous part be thick enough to prevent the poifon from reaching or entering

entering the blood-veffels, for that naturally difcharges its ftrength into the blood.

It is now time to treat more particularly of the beards or crooked hooks of the fting. If you put them under a powerful microfcope, you will fee them almoft like Cats claws, that is, they are fomewhat bent inwards, and their extremities are entirely tranfparent, but they are not moveable like the claws of beafts: the fhanks that conftitute the fting and their crooked hooks are all plainly cartilaginous and fufficiently flexible, but they are connected by no articulations.

No joints are obferved either in the fheath or the fting itfelf, though I was once of the contrary opinion. My error arofe from hence, that upon handling it the air run into the cavity of the cafe, and by its clearnefs or brightnefs, and by the bubbles it formed, rendered confpicuous the poifoned liquor, which ftill remained in the fheath, fo that it appeared to me as if the cafe itfelf of the fting was articulated or jointed.

If the fting be feen ftretched or protruded out beyond the extremity of the fheath, and at that time the Bee difcharges its poifon, then this poifonous liquor is not thrown out beyond the cafe, but appears upon it like a little drop. But when the fting is moift or wet, the poifon alfo is further diffufed, as it happens when the Bee gives any perfon a ftroke, and afterwards infinuates its poifon into the wound. Nor can it be otherwife, fince the fting, the hinder part whereof is thicker, ftops or clofes up the wound fo entirely, that the poifon has no entrance or paffage into it, but through the interftice of the fhanks of the fting itfelf.

Therefore the proverb applied to Bees is very true, "There is no honey without fome gall." Though I can find no bile in this infect, yet the poifon thus called gall may be diftinguifhed very clearly in it; nay, a great quantity thereof may be eafily collected: this I fhall at fome time endeavour to do, when I fhall make experiments on this poifon. It would indeed be eafier to obtain it out of the Hornets, Wafps, and Humble-Bees, the poifon-bladder of which is larger; but one cannot get thefe creatures in fuch numbers as Bees. If any one defires to examine the Bee's poifon-bladder filled with poifon, he muft kill the Bee, which may be done by throwing it into a bottle of fpirit of wine. The Bees may be otherwife killed without handling them, by the fmoak of that kind of fungus called crepitus lupi, or the puff-ball, or with that of linen cloth folded as in making tinder. The latter, in my opinion, is the beft way of killing them: for though you handle Wafps, Humble-Bees and Hornets ever fo little, they immediately difcharge their virus or poifon out of their formidable fting, and then none of it is found in the bladder, which is otherwife full of it. I preferve fome fuch bladders in my collection, as moft extremely meriting the infpection of the curious.

The poifon is collected in the following manner: draw the fting and poifon-bladder together out of the body, and then the bladder, as I reprefent in Tab. XVIII. figure v. being taken with the tip of the fingers, put the point or top of the fting into a thin glafs tube, and then prefs or fqueeze the poifon into the latter through the fting out of the bladder: you may afterwards blow the poifon together into another glafs veffel, and make the experiment thereon; but all this muft be done very fpeedily, fince this poifon is eafily coagulated when out of the body. Another method is to wound the bladder a little, and then to immerge or put into it the top of a thin glafs tube; and thus the humour will defcend fpontaneoufly, or be forced into the tube: but the former method is better than the latter for thofe who are expert in thefe things.

When the poifon is expreffed out of its bladder, it very eafily exhales, by reafon of its fubtile and fpirituous nature, leaving a confiderable cruft on the glafs, which when fcraped off appears like duft: whether this duft has ftill any poifon, is yet unknown to me. The poifon which the Bee difcharges through its fting in the form of a round drop, fometimes concretes about the fting itfelf, preferving the fame round fhape, and thus affords a very agreeable fpectacle, for it refembles a little drop of clear water, hanging as it were out of the fting.

When the Bee hath given a wound, the fting, as I have obferved before, ufually remains in the wound by means of its hooks. But whether the Bee can wound or pierce the fkin with its fheath only, and fo not leave its fting in the wound, is ftill unknown to me. The fheath is indeed very fharp. The Bee therefore feems able to wound with this alone, if it draws in the fting at that time; fince we likewife obferve, that this fting is not always equally prominent out of the cafe; it fometimes lies entirely out of the extremity of the fheath, and is fometimes lower and fometimes higher up in this its cafe.

When the fting remains fixed in the wound the Bee muft die; for, befides the fting itfelf, the Bee then lofes its inteftinum rectum, or the ftraight gut, and the parts annexed to it; nay, even the horny parts and their ligaments are broken off from the extreme rings of the body, to which they are united. And we are particularly to obferve here, that the whole poifon-bladder, together with the fting, is then drawn out of the Bee's body; and as it remains out of it, it ftill compreffes itfelf by the laft action of its mufcular fibres, and drives its poifon deeper into the wound. For this reafon, if any one be ftung by a Bee, it is by no means proper to take the fting by the hind part in order to extract it or get it out, becaufe, by this means more poifon is always thrown into the wound. It would be better to cut off with a pair of fciffors all the parts of the fting which hang out of the wound, and then to take out the

the reſt with a ſmall needle. I have ſometimes ſeen the ſtomach itſelf drawn with the ſting out of the body of the Bee.

If you would render the poiſon of the Bee ineffectual, and the Bee itſelf tame, make it thruſt its ſting into a piece of leather, and then cut off the top of it; by this means all the poiſon flows out of it, and the creature becomes tractable and gentle whilſt it lives, nor can it afterwards, though it ſhould probably generate poiſon anew, do any miſchief.

From what has been here ſaid, it appears how dangerous it is to irritate Hornets, ſince they have very formidable arms, and always carry poiſon about them.

In Hornets the poiſon-bladder is exceſſively firm, and is twice as big as in Bees. The learned Mouffet relates a very remarkable thing of theſe creatures: he ſays, the very accurate Penny ſaw a Hornet kill a Sparrow with a ſtroke of its ſting. Theſe are his words: "Whilſt Penny was at Peterborough in England, he ſaw in the ſtreet a Hornet in purſuit of a Sparrow, which it ſtruck at laſt with its ſting and immediately killed it, and, to the great aſtoniſhment of the ſpectators, fed itſelf with the blood of the dead Sparrow." How terrible theſe creatures are on account of this poiſon which they carry about them, is likewiſe evident from the promiſe formerly made by God to the Iſraelites in Exod. xxiii. "I will ſend, I ſay, my terror, like a Hornet before you, who ſhall drive out the Hivite, the Canaanite, and the Hittite from before thee." But God has no need of theſe hoſts to chaſtiſe his people; he can do it even by the ſmalleſt inſects, and convert the duſt of the earth into Lice, if the number of other plagues ſhould chance to fail: for what is above the power of him who ſhews himſelf adorable in all his works?

The queen or female Bee is furniſhed with a ſting, as I ſhall afterwards deſcribe in the diſſection of that kind. Among the Hornets the females only have ſtings, which are longer, ſharper, and ſtronger than in the Bee, and armed with ſeveral frightful hooks. How the males of the Humble Bees and Waſps are circumſtanced, in this reſpect, I have not been yet able to examine, on account of the variety of buſineſs wherein I am engaged. I would only have it obſerved here, that the males of the Hornet have no ſting, in like manner as the drone or male is without it among Bees; that the males of theſe two ſpecies agree in this reſpect, and are very peaceable creatures, free from all miſchief and injurious deſigns, and delight in love and generation only. There is the like meekneſs obſerved alſo in the males of Ants, and their teeth are therefore much ſmaller than thoſe of the females: among Ants alſo there is a third ſpecies which do not contribute to generation, but ſerve only to rear up their young.

I have before given my opinion of the principal uſe of this poiſon in the Bee, that is, I think it contributes to prepare what is called the Bee-bread into wax: this, however, requires to be yet more accurately inveſtigated. The whole ſting, nevertheleſs, great as it is, ſeems to be appointed only to do miſchief, and formed by nature ſolely for that purpoſe, that the Bees may, by the help of it, defend their young againſt the inſults of other creatures, and feed them in ſecurity. Since therefore the nouriſhing of the ſtock is committed to the common working Bees, hence it ſeems probable that they, particularly about the time of ſwarming, and a little after, are as furious and as much inclined to ſting and do miſchief with their poiſon, as they are eager to preſerve as well the iſſue committed to them, as their own proper food. It would not be improper to conclude from thence, that the ſting and the power of doing hurt with it, are given them on that account. The truth of this will be more evident to any one who conſiders that the females of the Hornets are likewiſe provided with ſuch weapons, though they never form any wax, but build their habitations principally, as it appears, of the bark of trees faſtened together. Hence various colours are obſerved in their neſts, according to the variety of the bark of trees which they have uſed in building them. We likewiſe ſee in the time of copulation with what fury the Stag ſtorms and rages if any one comes near him: this Harvey very accurately deſcribes from experience. Nay, even the otherwiſe inoffenſive domeſtic fowls will fly in the face of thoſe who endeavour to take away their young, and even Bitches and Cats, however mild and gentle they are, yet cannot endure to have their whelps and kittens touched. Theſe are the arguments which nature ſupplies for eſtabliſhing the uſe of the poiſon. But that the poiſon, in preference to any thing elſe, is given to theſe inſects with deſign to hurt mankind and all other animals by it, and that their ſting alſo, as ſome think, is made to torment and harraſs the human ſpecies for the hereditary ſtain of mortal ſin, is moſt abſurd, and plainly contrary to the infinite goodneſs of God: he does not vex or torment but kindly chaſtiſes, unleſs when the number of their ſins voluntarily committed are increaſed beyond all meaſure. I ſhall here conclude this diſſertation on the working Bee, ſince it is not granted to us to ſearch perfectly into the divine works with our limited ſhallow underſtandings *. I have propoſed the matter, and with my own hands deſcribed and delineated the ſituation, ſtructure and uſe of their parts,

* The Bee has been honoured with the notice of philoſophers from the earlieſt time. What Virgil has ſaid of this inſect is principally from Ariſtotle. Theophraſtus has alſo wrote expreſsly on them, and we read of a greek naturaliſt who retired from human kind, and paſſed a long time in the woods to obſerve them. But the labours of all theſe anſwered little purpoſe: it is not till very lately that we have underſtood their nature, and we owe more to Swammerdam than to any one author in this inquiry.

parts; and therefore thefe various obfervations may be of ufe to us, until it pleafes God to throw more light on our knowledge of the fubject; for in this way we may at length moft eafily know the Architect of nature, from whom we are the further removed, the further we proceed, if we only indulge our own vain reafonings.

The order I have prefcribed to myfelf requires that I fhould now exhibit the anatomy of the female Bee: I fay, the female, which, as it is a diftinct infect found in the hive, fo it is by a common error generally dignified with the glorious title of king, though by fome it is more properly called the Mother-Bee. I fhall endeavour to follow fuch a method in this hiftory, that, as the female has many parts in common with the working Bee, I fhall only defcribe thofe which that kind has not, together with fome others, which I have obferved more clearly in the female. Among thefe I mention in the firft place, the heart. Tab. XIX. fig. I. *a a*. This is a tube pretty ftrong and fibrous, it is oblong, and here and there dilated, it is extended in length from one end of the body to the other, and then turning about, it paffes through the narrow little part or horny tube, which, like a thin filament connects the breaft with the belly. In order to difcover the heart in the abdomen, as in that part it may be beft feen, it is neceffary to diffect or lay open the horny rings of the body with fciffors or a knife, taking care at the fame time not to hurt any of the parts that are under thefe rings; for the outermoft part of the rings of the body is fo thin and tender, that not only the pulmonary tubes may be feen tranfparent through them, but one may alfo diftinguifh, though obfcurely, the motion of the heart under it. The pulmonary tubes in the female are not fo frequently divided or expanded into bladders as in the working Bees, which difference is fo ordered by nature, that the working Bees may fly the more conveniently and expeditioufly; whereas the female is underftood to fly but once a year, that is, when they fwarm. However, I cannot entirely agree with this tradition, but rather think the female goes out of the hive in fair weather, in order to breathe a purer air. It muft be obferved, with refpect to the diffection of the body, that its rings are at their origination of a full redifh brown colour; but of a yellowifh red where they become membranaceous. In the midft of them are feen two or three blackifh lines, and the extremities of the rings grow black again, and are very thin, and provided with a horny verge. This obtains only in the lower parts. If the upper part of the ring of the abdomen be broken and carefully raifed up, as I have before advifed, the heart, Tab. XIX. fig. I. *a a*, immediately comes in fight, and appears to be fituated in the uppermoft region of the abdomen, and is furnifhed with many fmall and delicate air-pipes *b b b*, which iffue from each fide, and are inferted in the fubftance of the heart. Thefe air-pipes or pulmonary tubes are fupported by fome tender and very delicate membranes *c c c c c*, which keep the fat that lines all *d d* about and underneath them in its place. Through thefe little membranes, and on each fide of them, in fome places, a fubjacent ovary *e e e* is found to fhew itfelf. If the diffection be made in the manner I have directed, about the fat of the little membranes that connect the extremities, there will be feen alfo fome mufcular fibres, broken off from the rings of the abdomen, which ferve to move the mufcles *f f f f f*. Under the fections alfo, between the fat, fome mufcular fibres prefent themfelves, which feem to contribute very powerfully to dilate and conftringe the heart, and at fome times to pufh the air through the compreffed pulmonary pipes towards the heart. Even the membranous fibre which connects the fat, likewife embraces the whole ovary underneath, which by this means comes in view; when that membrane is carefully cut, the heart removed, and the great number of pulmonary tubes which are connected with the ovary and heart, and this membrane and the fat are removed. The numbers Tab. XIX. fig. I, 1, 2, 3, 4, 5, 6, denote the rings of the abdomen, under which, as in the back, the heart is fituated.

The greateft part of the ovary is lodged in the uppermoft region of the abdomen, and ftands as a partition between that part and the breaft, fo that the other vifcera, that is the ftomach, inteftines, vafa crocea, or yellow veffels, and others, are placed much lower in the body.

The ovary is divided into two parts, fig. III. *a c*, in the fame manner as it is in the human fpecies, in quadrupeds, fifh, and many other fpecies of infects, and even in frogs. Thefe parts of the ovary are more or lefs feparated from each other in thofe different animals, but here they lie contiguous to one another; one part indeed is placed in the right, another in the left fide of the abdomen; befides, the ovary here is fo firmly connected by the pulmonary tubes that run through it, that it cannot without difficulty be feparated.

The ovary appears to the eye as a membranaceous little part, fo wonderfully delicate and tender, that the containing membranes are fcarce any hindrance or impediment to the enclofed eggs being diftinctly feen through them.

The ovary, as I have obferved, is divided into two parts, and each of them is again fubdivided into two fingle parts, which, for diftinction's fake, may be called the oviducts, though they in reality conftitute the ovary itfelf, and give to the eggs which lie in their cavities both coats and fubftance, and whatever elfe belongs to their nature. This, however, is otherwife in birds and fome of the quadrupedes. In the larger animals, and in the human fpecies, there is obferved a confiderable difference as to this matter; for the human fpecies, as alfo quadrupeds, Cows, Sheep, Dogs, Cats, Rabbits,

and

and the like, acquires their full perfection in the ovary, and are from thence afterwards conveyed through a paffage made for that purpofe only, the fallopian tube, at once into the uterus, nor do they fuffer any change in all this journey. In Birds, on the contrary, the egg is but half perfected in the ovary, the yolk only being formed there; but the white and fhell is afterwards added to this in the oviduct called their uterus. In fome quadrupedes, as Frogs, the whole animal, which appears at firft in the form of a round egg, acquires its full perfection in the ovary, but it is afterwards covered over in the oviduct or tube, with a vifcous matter, with which it defcends into a kind of hollow enclofed membrane, which is their uterus: this vifcous matter is the firft food the animal fwallows. In Bees the egg obtains its beginning and perfection in the ovary, which performs the office of an oviduct, tube, and uterus or womb, all in one. This ovary appears to the obferver at firft like a fmall and fimply membranaceous tube; but in reality there is a neceffity for much more apparatus. But our imperfect refearches can go no further than our eye-fight reaches.

Behold, then, after what manner the omnipotent Architect hath retrenched, as it were, feveral parts here from the ufual oeconomy of nature, and contracted them into one!

In the Silk-worm's Butterfly, the ovary is in this manner alfo divided into two parts, and each of them again divided into four others, which I call oviducts, whofe ends or extremities are of a fimilar ftructure with thofe of Bees. In the Rhinoceros Beetle alfo the ovary is in the fame manner divided into two parts, each of which is again divided into fix oviducts. In the Humble Bee I found each fide of the ovary feparated into four parts. In the Wafp, which lays more eggs than the Humble Bee, I faw the ovary, Tab. XIX. fig. IV. *a a*, divided on each fide into feven oviducts. But here in the female Bee fo many oviducts occurred, that I was not able to reckon them; for not only the great number of the divifions prevent the counting them, but alfo the extreme tendernefs of the texture; whereby they are very eafily deftroyed under our hands: to this may be added the very ftrong knots, by which the pulmonary tubes bind thefe oviducts to them. Nor could I any more reckon how many eggs there were in each of thefe oviducts; but this is very eafily done in the Humble Bee, in whofe oviduct I computed ten larger, and fome fmaller eggs. In the Silk-worm Butterfly I have fometimes counted fixty or feventy eggs in each oviduct; but in the Bee I could by no means determine the number of the eggs: in another ovary I counted fixteen or feventeen large and fmall eggs in one duct; fo that the Bee has a fmaller number of eggs in each oviduct, than the Silk-worm Butterfly. I afterwards attempted to count the oviducts in another female; but here again I had as little fuccefs, both on account of the ftrong connexions of the parts one with another, as becaufe I could not fpare the neceffary time. Upon comparing the numerous oviducts, which I had found with the greateft labour, with thofe in the other part of the ovary, which I had not computed, I think I may venture to affirm that there were more than three hundred oviducts in the ovary of the Bee. And hence, if this number of 300 oviducts be multiplied by the number 17, (for there were fo many diftinctly vifible eggs in one oviduct, when the female was entirely perfect,) it will refult from the whole, that there are five thoufand and one hundred vifible eggs in one female Bee, and yet thefe fo different from each other in fize, that one would be furprifed; for thofe that are to be laid laft, are no more than rudiments fo fmall as to efcape not only the eyes, but even my beft microfcope, and are to be numbered by Him alone who formed them. The extreme points or ends of the ovary, which contain thefe minute eggs, are placed in the uppermoft and higheft region of the belly, and are there as it were folded and turned back. The fame thing is feen in the Humble Bee, and Wafp, and alfo in the Silkworm Butterfly; but in the Wafp the ovary terminates in wonderfully long productions, Tab. XIX. fig. IV. *b b b*, which are fo interwoven with the pulmonary tubes, that one would think them a little net compofed only of thofe tubes. It is to be obferved that I here reprefent a double ovary, and that one of its fides, fig. III. *a*, is taken out of a fully pregnant female; the other out of one *c* not fo far gone: and hence a great difference arifes in the form of the ovary. The eggs, *f f*, *i i i*, which are reprefented in the extremity of the Bee's oviduct, that was not fo far gone in her pregnancy, are by far more numerous, fmaller, paler, fhorter, and more oval, as alfo more pellucid and tender than thofe which are fituated in the lower part of the oviduct; out of which the eggs finally iffue and are produced. This is conducted in the fame manner by nature in other infects, I have obferved it in the ovary of the Loufe, but in the ovary of the Frog all the eggs are of the fame fize: in the human fpecies, in quadrupedes, and birds, they always differ in magnitude. And it muft be here obferved, that in the ovary of the lefs forward female, fome eggs appear larger than others, fig. III. *l l l l*; though they be already come down to the lower parts of the ovary. But this, as I have obferved, I never faw except in females, which did not increafe their colony as they fhould have done, and when there was fome confufion in the hive: therefore I really think that the female's ovary has then fome fpecies of a diforder. And hence I have, in order to prevent the neceffity of two figures, on one fide *a* delineated part of the ovary of the real pregnant female Bee; for thofe are now called queens or females by our Bee-keepers, which enrich the

hive

hive with a numerous off-fpring, and plenty of wax and honey; and it is there obferved that the eggs *g g*, *h h*, are almoft all of a fize, and by degrees decreafe the higher they are fituated. The extreme ends of the oviducts refemble in the real prolific Bee *f f*, delicate, fine and fcarce vifible filaments, which are likewife crooked at their extremities, and are furnifhed with rudiments of oblong and almoft equal eggs, which at laft become fcarcely vifible.

Where the ovary is more protended or ftretched downwards in the lower region of the abdomen, it there terminates in two very confiderable ducts *b b*, *n n*, which refemble the two cornua or horns of the uterus in quadrupedes. All the other oviducts open into them, and bring their eggs thither, which is the cafe not only in the true female prolific Bee, but alfo in the others, though in a lefs regular manner. Thefe two ducts are dilated by degrees, and become fo confiderably larger; that they appear at length like a globular mafs *p p*; but when I opened them there, in the real prolific female, I found in each fide nine or ten eggs *q q q q q*, which had defcended fo far, and are there probably covered with a ftronger coat or tunic, or are changed and prepared in fome other manner, fo that they may be afterwards emitted with fafety out of body; for the Bees do not lay their eggs as they naturally fall, like hens, but fet them upright. Thefe eggs, Tab. XIX. fig. III. *q q q q q*, here likewife appear though faintly through thefe horns of the womb if it be proper to give them that name. For the uterus or ovary is in that part fibrous or mufcular, and therefore is of a proper texture to pufh the eggs forward, and expel them out of the body; nor do I doubt but the oviducts have alfo fome mufcular fibres. A little lower, near the extremity of the body, thefe two horns of the uterus become narrower again, and at length they unite in one canal, which is likewife fibrous, and has a kind of periftaltic motion *f*. The fpinal marrow paffes through the extremity of this aperture, which is left between thefe two ducts near where they are to unite *o*, indeed juft above the place where this union happens; and there give fome nerves to the ducts, by the help of which they acquire a power of moving, and the infect is enabled to difcharge its eggs at its pleafure. This is the method wherein the fpinal marrow paffes through the ducts of the ovary in Humble Bees, and the fame is feen in Wafps. Many pulmonary tubes are alfo fixed into thofe two horns of the uterus *r r r r r*, and the whole ovary is in like manner furnifhed with many fuch pipes: it receives them on each fide from the dilated pulmonary tubes, which are the pneumatic bladders or lungs of the Bee. I exhibit fuch an oblong bladder *d* in one fide, where the ovary of the not fully perfected Bee is exhibited, that it may be feen by what means that bladder tranfmits its ramifications into the part of the ovary fituated on that fide. Thefe pulmonary tubes are diftributed through the whole furface of the ovary, but they are feen chiefly about the eggs themfelves: this I have reprefented in a very fmall egg, as may be feen under the letter *b*, in fig. V. The egg is there delineated magnified together with all its pulmonary tubes. In the extremity of the body is afterwards feen a fmall part exactly globular or fpherical, fig. III. *t t*, containing a flimy matter in it, by means of which the ends of the eggs are faftened in their waxen cells. About this globe part two other exuberant parts are to be obferved, like crooked horns *u u* terminating in one foot-ftalk or tube. Thefe are afterwards inferted in the uterus. This tube draws the matter contained in the fpherical particle out of it, Tab. XIX. fig. III. *t t*, and with this matter afterwards moiftens the eggs that pafs through in order to be laid. Thofe two veffels *u u* have their extremities clofed up, and feem to me to fecrete the glutinous matter found in the fpheric bag, and to depofit it into the latter; unlefs the glue be rather fecreted in the bag itfelf, which I rather believe. Thefe clofed veffels are likewife very remarkable in Humble Bees; but the bag has a different figure in that infect. In the Hornet the bag is likewife fpherical, as it is here in the Bee. In Wafps it is of a pear-fhaped figure, fig. IV. *c*; but the clofed veffels, or thofe which fecrete the flime, if it be fo, are not fo large, or remarkable there as in the Humble Bees or Bees. In the Silk-worm Butterfly thefe veffels are very confpicuous, but there is no fuch bag of flimy matter there. The fpheric particle or the bag of flimy matter in the Bee, has two coats, the outermoft whereof is whitifh, mufcular, and in a wonderful and very beautiful manner interwoven with an infinite number of pulmonary tubes, fo that one would fay it was wrought with a needle. The outward coat may be eafily taken off from the under one; and when this is done, that little part appears more exactly globular, and becomes of a faint purplifh colour, variegated with white fpots. If the inward coat, which is thicker and more glandulous than the former, be opened with a fmall pair of fciffors, a turbid or thick moifture flows out of it, which is like glue; it fticks to the fingers, and may like filk be very eafily fpun out into threads, which immediately grow dry in the circumambient atmofphere. By the help of this flimy matter the female Bee fixes its eggs in the cells: the Hornets and Wafps alfo glue their eggs fo firmly in their places, that they cannot be afterwards removed without injuring them; but the eggs of the Humble Bees are not fo firmly fixed. I have obferved fomething fingular in thefe, and therefore I fhall delineate the method whereby this fixing of them happens, after I have finifhed the hiftory of the female parts. The Silk-worm Butterflies likewife have their peculiar clofed veffels, which contain the flime that ferves to fix their

eggs.

eggs. I have likewife obferved the fame thing in lice of the human head, which differ from thofe of other animals greatly. Thefe have a confiderable ovary, likewife divided into two parts, each of which is again divided into fix oviducts containing a great number of eggs or nits. Thefe eggs likewife differ from each other in bignefs, and when they approach to being laid, thofe that are firft laid and faftened down are much larger than the latter ones: this is likewife the cafe in Wafps, whofe eggs are fmall and oval, Tab. XIX. fig. IV. *d d*. The bag of flime has, as I have obferved, on the lower part or otherwife on its fide, an oblong duct, by the help of which it is connected with the excretory paffage of the eggs, fig. III. *x*, and therefore when the eggs pafs through their excretory paffage in that part under the tube of the bag of flime, they are covered over with its flime, which makes one end of them afterwards, when they are difcharged, adhere to the wax; but how or where the orifice of this excretory paffage is χ, and what parts are to be feen there, I have not yet obferved, fince very few females are to be found in thefe unhappy times, whofe wars and flaughters have deftroyed even the Bees in our country: to this may be added, that what has been laid down cannot be feen fo exactly, unlefs the hinder parts of the body of the Bee are taken out, which I would not attempt, becaufe the reft of the parts were in this experiment to be preferved; therefore I have nothing more to fay on this fubject. I fhall only obferve that the letters *y y* indicate the external mufcular parts of the fting, as naturally bent δ, when broke off. *z* Exhibits the poifon bladder with its tube α, and clofed appendages β β, and its tube γ, protended or ftretched towards the fheath of the fting. ζ Reprefents the laft gut called the rectum; all the parts before recited are here expreffed in their natural form, but greatly magnified. There are likewife feen two little parts ε ε, wherewith the fting is furnifhed on each fide; thefe we have feen defcribed in the hiftory of the common working Bee, which has them in common with the female.

As to the ftomach, inteftines, vafa crocea, or yellow veffels, and other parts, all thefe are conftructed in the fame manner in the female, as I have before defcribed them in the working Bee. I thought I obferved fome fmall difference in refpect to the colour, as well as ftructure and fituation, in thefe little oblong parts, which I examined in the cavity of the working Bee's inteftine, where this is at length dilated.

The poifon-bladder is likewife very remarkable in the female Bee, being throughout pellucid, clear, and perfpicuous like a diamond; it is as large again as in the working Bee. The tube, being confpicuous in the hinder part of this bladder, may be more eafily difcovered here than in the working Bee: and the other tube which is extended from this bladder towards the cafe of the fting, is alfo ftronger and fomewhat longer in this than in the working Bee, but as the humour contained in this bag appears to be fo perfpicuous and agreeable to the fight, I have endeavoured to tafte it, taking care at the fame time that I fhould not tafte fo much of it as that it could do me harm. This liquor firft affected the tongue with a bitterifh tafte, which afterwards became more acrid and pungent, diffufing itfelf through the whole cavity of the mouth unto the jaws, and forcing the faliva out of its ducts, and indeed the tongue was affected in the fame manner, but lefs violently, as with the root of pellitory of Spain. There was likewife a great motion made by it in all parts of my mouth, as if I had tafted ten or twelve drops of the moft highly rectified fpirit of wine; after this, becoming more bold, I tafted the poifon of other Bees, and of Wafps: all were alike, only that I difcovered that the poifon in the working Bee was not fo vehement as in the female; and again, that what is in the female is more mild or gentle than the poifon of the Wafp. What wonder is it that a very fmall drop of this poifon being violently driven between the skin and flefh, and immediately mixed with the mafs of blood, fhould produce fo much pain, pulfation of the arteries, fwelling and inflammation to that degree, that not only a fever, but death alfo would enfue thereon, if many ftings were inflicted at once. If a fmall piece of glafs, or a little wooden fplinter, be ftruck or fixed in the finger, it caufes the moft violent pain, what muft be expected therefore from this fharp and moft penetrating liquor, which corrodes at the fame time, fixes itfelf violently in the parts, diffolves their continuity, and at length creeping into the blood-veffels, diffufes itfelf, and circulates with the mafs of blood through the whole body? it is a common obfervation among the vulgar that fix Hornets are fufficient to kill a horfe.

The fting, together with all its parts, is conftructed in the female almoft in the fame manner as I have before defcribed it in the working Bee; the only difference I obferved was that it is more remarkably bent in the female, though at the fame time it is very fharp; this is probably the reafon, that the female does not naturally wound with its fting, nor can it do it eafily: from this was afterwards framed the fable that the king, for fo they called the female, has no fting, and is of a mild difpofition. The female certainly threatens a ftroke, at leaft, when fhe is provoked, as I have learned from experience. But what the real ufe of this poifon is, if we are certain that it is given to Bees for fome other purpofe befides that of defending their offspring, in doing which they lofe their lives, I fcarce fee how it is poffible to difcover. I formerly thought it might poffibly ferve to make the wax; but the Wafps and Hornets deftroy this opinion, which are furnifhed with a fting and poifon, though they make no wax. Nor does the female Bee prepare any wax, nor even defend its young; fo that this ufe alfo may be queftioned or difputed. Behold then, reader, how difficult it is to inveftigate nature in her works, and learn with me, to clofe your lips, and candidly confefs our general ignorance and weaknefs.

The firft obfervation on the female Bee.

THE better to illuftrate what has been here advanced of the fting and its poifon, as alfo of the ovary, I fhall add fome particular obfervations, which I have fince the writing the former account made on the female Bee. On the 16th of June I opened a hive, and I found in it feveral fovereigns or females, which were foon after to fwarm, yet lying covered in their waxen cells. Of this I was very certain, becaufe I found them with their skins caft, and with expanded wings, nay they were ready to arife out of their cells. In the firft of thefe which I diffected, an ovary occurred, but was not very diftinctly confpicuous. I was obliged to make ufe of a powerful microfcope to examine it, but then I faw that there were numerous oviducts in it, and the eggs themfelves as it were innumerable on account of their fmallnefs: I really think there were ten or twelve thoufand of them. I could diftinctly have counted them, if I had had a mind to have undertaken the laborious office of feparating them from each other: the eggs themfelves, compared with thofe which I had before obferved in the female Bee, at the time fhe is engaged in laying eggs were ftill very fmall, nay, thofe which were in the extreme ends of the oviducts were fo wonderfully minute, and fo thick placed together, that I could not diftinguifh them, but by the help of my moft powerful microfcope. I have likewife obferved the ovary invefted here as with a common membrane, which I confefs I never before faw fo diftinctly.

The fecond obfervation on the female Bee.

IN a fimilar female Bee, produced at the fame time, but more mature, which, with fome thoufand of other Bees had fwarmed out of its native hive, and was received into another, I faw that the ovary was likewife yet confiderably fmall, nor did even the eggs appear much larger, than if they were yet in their rudiments; and hence I concluded, that this female was but juft excluded from her cell, when fhe flew away in this fwarm out of her native hive. I could not in that fubject obferve many remarkable things further, nor in others, though I had many females ready, for all of them died in the fpace of one or two days. But though I threw them into fpirit of wine to keep them from drying, yet many of the vifcera were, to my great concern, fpoiled: the reafon of which was probably becaufe I did not make ufe of a fpirit fufficiently rectified. I obferved that the poifon in fome of them was converted to a white matter, nearly without tafte or ftrength, which when expofed to the air dried up and evaporated. In another I faw the poifon feparated and condenfed into irregular white grains, and I could very diftinctly fee in that Bee the whole poifon duct, which is connected with the hinder part of the poifon-bladder, and which perhaps fecretes the poifon, covered over with coagulated particles of fat, which could not be eafily wiped off.

The third obfervation on the female Bee.

I OBSERVED in another female, which I diffected about the fame time, that one of the extremities of the poifon duct was fubdivided into two other clofed but fhort appendages. When I meafured the poifon duct, from the bag to its firft divifion, I found it to be a quarter of an Holland inch long, and that one of the branches of this divided duct was almoft half an inch long; and the other almoft two inches. However, thefe things cannot be obferved, unlefs one has firft very cautioufly feparated all the curvature and ferpentine windings of thefe ducts from the reft of the vifcera. Though this Bee had likewife lain in fpirit of wine, yet all thefe parts were very diftinctly confpicuous and ftrong in it.

The

The fourth observation on a prolific female Bee.

IN a truly prolific female Bee which had ſwarmed on the 24th of July, and had laid many eggs, I obſerved ten or eleven days after that I diſſected it, that the beginning of the ovary was furniſhed with a great number of perfect eggs; but the eggs that ſtill lay in the appendages of the oviducts, were not of that ſize or perfection which they are obſerved to have in the oviducts of the prolific Bees diſſected in the month of May, at which time they are moſtly employed in laying their eggs; nor were they ſo perfect as the eggs of the females examined in the months of autumn, as will be made evident in the fifth obſervation. From all this I diſcovered, that the female which had ſwarmed was young, and newly produced from her cell. But whether all thoſe that ſwarm are young, I cannot yet preſume to affirm for certain. Not only thoſe eggs which were in the lower part of the beginning of the oviducts, but thoſe which were ſituated higher had arrived to their perfect ſize. This ovary likewiſe had in it an infinite number of eggs, ſo that in only fourteen little parts which were broken off from the appendages of the oviducts, I reckoned one hundred and ſeventy four eggs. Hence it is not difficult to judge what a ſtupendous number of eggs one female contains. But there was a neceſſity for ſuch a formation and conſtruction, ſince a whole hoſt of Bees of all the three kinds were to proceed from one female, as is actually the caſe. This numerous family not only contains three, four, or five thouſand Bees, but ſometimes nineteen thouſand, as hath been obſerved elſewhere. I likewiſe in this ſubject diſtinctly ſaw all the oviducts on each ſide of the ovary unite in five principal branches, with which the reſt of the oviducts were connected, and through which each conveyed its eggs into the common ducts.

Notwithſtanding all the pains I took, I could not diſcover the orifice of the ovary or vulva in this Bee, becauſe I was in the country and had not all my inſtruments at hand, and becauſe I did not take the vulva out of the hinder parts of the body, fearing leſt I ſhould hurt any of the parts which I thought neceſſary to examine. However, I ſaw very diſtinctly that the excretory duct of the eggs, Tab. XIX. fig. III. *f*, where it approaches to the laſt ring of the body, dilates itſelf into a muſcular globule, and then growing narrower, at length becomes again wider and more membranous; but I could not proſecute this inquiry any further, becauſe I deſigned to keep unhurt the poiſon bag, which is ſituated in that part, together with ſome particular muſcles that belong to the ſeveral parts of the ſting. In another female I thought I obſerved that the orifice of the vulva, when the Bee lay on its belly, opened under the ſting in the laſt ring of the abdomen, and that it is very difficult to penetrate into this orifice, unleſs the parts be expanded and raiſed at the time the Bee is laying eggs. I likewiſe ſaw the fundament very plainly, and its orifice opening above the two appendages of the ſting: it was placed in reality juſt over the ſting and the two little parts juſt now mentioned. I further diſcovered that the rectum or ſtraight gut had a kind of cavity there, which was full of red and yellow excrements, but that the inteſtine itſelf was formed in the manner exhibited in Tab. XVIII. fig. I. letter *l*.

I have moreover obſerved that theſe two obtuſe appendages, which the aculeus has as it were for ornament *o o*, are in reality the productions of thoſe cartilages, which I have figured in Tab. XVIII. fig. II. *l l* and *m m*. But the true uſe of theſe appendages ſeemed to me to conſiſt in this, to try beforehand whether objects be ſoft or penetrable to the ſting, that the Bee may not in vain dart its ſting againſt harder bodies, and ſpoil it to no purpoſe. I obſerved alſo, that one ſide of theſe little parts was covered with a cartilaginous integument, and ſet round with fine hairs.

Since the ſting with all its parts was here in the female conſiderably larger than in the working Bee, I could therefore diſcover ſome ſingular things about it which I had never obſerved before. I firſt obſerved, that the ſheath itſelf of the ſting had two ſhanks, to which the ſhanks of the ſting itſelf were cloſely applied, ſo that the latter may by the help of the former, be more regularly moved. Theſe ſhanks of the ſheath were in this Bee alſo very beautifully bent like the ſhanks of the ſting. It is ſcarce credible how beautiful the ſtructure of theſe is near the ſheath; for there I obſerved likewiſe two ſmall parts, which being at their origin bent into an oval form, had a verge or border of a brown full red colour; but afterwards acquiring by degrees a paler tinge, and uniting in a point, they were on one ſide articulated with the cartilages before exhibited, Tab. XVIII. fig. I. *n n*, with which the extremities of the joints of the ſhanks of the ſting were likewiſe connected in the upper part. The little bone alſo, which I have before deſcribed to be like that in Birds, called ſpecillum, was obſerved to be articulated in the hinder part with the caſe or ſheath itſelf; but the poiſon duct paſſed there only higher up, and immediately terminated after it had advanced a little way in the ſheath. Whether all theſe ſeveral particulars be circumſtanced in the like manner in the working Bee, I have not yet examined.

I further learned from this diſſection, that the two little parts fig. III. *r r r*, which I have before exhibited in the common Bee, as ſituated on the outſide of the ſhanks of the ſting, were here in reality placed on the inſide of them. I likewiſe ſaw very diſtinctly, that the muſcles moving

moving these ſhanks upwards out of the ſheath, and again drawing them downwards into it, lie in reality in the female between the margins of the ſheath in the hinder cavity of it, and are there inſerted in the two parts juſt now mentioned. Thus I at length found that theſe two little parts principally and chiefly contribute to keep the ſhanks of the ſting, whereof they contribute a part, in their places and prevent their ſlipping out of the ſheath; and this they can do more eaſily, as they themſelves are contained in the cavity of the caſe, out of which I have, with the aſſiſtance of a microſcope extracted them, and afterwards put them into it again without the leaſt hurt to any part.

I have likewiſe at length diſcovered the true reaſon why I had not before diſcovered in the working Bee what I have juſt now ſaid: and it was this, that the ſhanks of the ſting when drawn out of the ſheath, inſtantly bend themſelves, and hence it then happens that theſe two little parts always appear on the oppoſite ſide.

The fifth obſervation on a real prolific Bee.

IN a female Bee brought to me in autumn, at the time when the honey is taken from the hives and the wax alſo, and for which reaſon two hives are ſometimes then formed into one, I diſcovered the whole ovary to be ſtill full of innumerable eggs; ſo that I have from hence learned that the Bees never lay all their eggs together, as is the caſe with Hens, which commonly clear their ovary entirely, leaving only ſome ſmall rudiments behind. I therefore think, ſince the eggs in the ends of the oviducts of the Bee are innumerable, and lie diſpoſed in an delicate order, that they are continually diſcharged out of it, and ſucceed in the place of thoſe eggs which were before laid. In this female, which I preſerved for the ſpace of a whole year in ſpirit of wine; the poiſon was likewiſe coagulated and ſtuck in its bag like an oval particle of wax, but ſo as that the inward ſurface of the bag was ſeparated all round from the ſurface of the contained poiſon.

As I had many Bees at the time when theſe females were brought to me, I had an inclination to try what would be the conſequence if the poiſon was mixed with the Bee-bread. The following was the event of the experiment. The friable and otherwiſe very eaſily ſeparable Bee-bread, which is not naturally fit for working or kneading, nor is at all glutinous, was, by the admixture of the poiſon, inſenſibly rendered tenacious and clammy, and having loſt all its friability, began to melt in ſome degree at the fire, but it grew black after ſome time, exhibiting its former appearance of bread, which never catches the flame, but only grows black in the fire. The ſame maſs thrown into water was not diſſolved, but being ſomewhat agitated in the water, returned to its former diſpoſition, and at length began to melt. Some particles of Bee-bread kneaded or wrought with the poiſon, and kept fourteen days, retained their acquired tenacity, nor did they again become friable; but whether any thing can be inferred from this experiment I would not yet preſume to determine *. It ſeems at leaſt in ſome meaſure to follow from thence, that there is no reaſon to deny the Bee-bread, or that matter which the Bees carry fixed in their legs, and which is of a ſimilar nature with the Bee-bread, may be made into wax. But when I began this experiment, I had not the matter now mentioned at hand; nor could I get it, as the hives were carried at that time into ſome fields of buckwheat which was then in flames.

I have frequently offered the Bee-keepers a conſiderable preſent, if they would ſhew me real wax adhering to the legs of Bees: but though they readily undertook this, they never could perform it. Therefore the method whereby wax is made, muſt it ſeems yet be referred to or reckoned, amongſt thoſe things which we are hitherto ignorant of, and which ought to be inveſtigated. The ſame doubts may be raiſed concerning the making of honey, though this difficulty may be more eaſily removed. I have not hitherto been able to make all the experiments concerning this matter which I had deſigned. I ſhall therefore conclude theſe obſervations on the female, after I have firſt exhibited the manner of ſeeing diſtinctly how the Bees make the wax. For this purpoſe I ordered a wooden ſtool with three or four feet to be fitted into a ſtraw hive, in ſuch a manner that the hive might be conveniently taken off and again laid on it. I covered the edges of this ſtool with paper, and then in ſwarming time I put a new ſwarm into the hive. When I afterwards ſaw, that the Bees in the inſide had made wax and propagated young ones, which happen in ten or twelve days. I immediately removed the hive from that ſtool, and alſo took away the paper, and thus I could very diſtinctly ſee the Bees working in the ſun-ſhine. But though I have never gone through with this experiment, yet I know the effect of it, for I have often ſeen that the habitation of the Bees which had made

* In fine weather the Bees conſtantly go out in ſearch of the matter of wax, which they collect from the antheræ of flowers. They eat ſome, and lay up the reſt in certain cells of the comb where it is preſſed down by other Bees, and this ſerves them to eat in bad weather, when they cannot go out. After they have ſwallowed this, and it has paſſed the operations of their ſtomach, it is wax, which they complete by more working and moulding; but though the farina of flowers be the real ſubſtance of wax, human art can never make wax from it.

their

their nefts in the holes of old walls and ruins of houfes, was a full fquare foot wide at the mouth, through which their making of wax, and other operations might be feen conveniently. We fhould not therefore fear that the Bees when expofed thus openly will defert the hive, which is the only objection that one can make againft the propofed experiment. The fear of their flying away will be the lefs, as they will have placed their offspring there before the operation, which they never afterwards relinquifh. If any one fhould fear left the Bees fhould be injured by the nocturnal cold, he might cover them at night with a larger hive or any other larger cover. And in the day time they might be put in fuch a place that they fhould not be expofed to the injuries of the heat or rain.

I fhall now proceed to the hiftory of the male Bee; and here fhall firft briefly relate fome things of Humble Bees and their eggs. The Humble Bees, as far as I have obferved, do not build nefts or live together, but in the winter; like moft other infects they abftain from food and motion, and therefore they are properly folitary Bees. I have feen, however, that about the end of May, or fooner, fome few male Humble Bees, and one female which is of a larger fize, gather together in the paftures and corn-fields about Amfterdam. The place they choofe to build in is between the ftalks of corn or grafs, and is not deep under the furface, but only a little hole burrowed under the grafs, in which hole there is found either naturally or heaped together by them, a tender foft fort of down or mofs, on a fmall part of which, formed in a kind of bed, with brown wax or a flexible matter like it, the female lays her eggs. With this matter alfo the eggs themfelves are all fealed up underneath and on the fides. But in what manner thefe eggs are depofited there, and how the young and tender Worms creep out of them, and whether they eat this fubftance, I have not yet learned from experiments. I have lately however, namely, on the 22d of June this year found a perfect neft, in one fide, Tab. XXVI. fig. 1. *a*, of which there were eighteen cells, but in the other *b* only eight. Between thefe was feen one cell entirely empty *c*; and there occured in feveral places here and there *d e f* fome particles of the fame kind of waxy matter: in this the eggs were all clofed up. I fhall now diftinctly defcribe what I could obferve upon this occafion. I found one female and feveral males in this neft, all which fhewed by their humming and their running anxioufly up and down, that my curiofity was by no means pleafing to them. When I afterwards carefully viewed eighteen cells, and opened them by cutting off the piece *g*, I found them all full of little Worms, which were to be transformed into Nymphs *h*. Upon obferving the ftructure and fubftance of thefe cells, I found that they were all compofed of threads or filaments, and were of an oval figure, and of a colour fomewhat approaching to yellow. This I looked upon as a ftrong argument that thefe little cells were not made by the Humble Bees, but by the Worms themfelves: nay, a certain, though not very exact order, was obferved in their compofition, fince one cell was placed in the middle and furrounded by five others. They were all faftened together in the fame manner in which the Silk-Worm is accuftomed to affix itfelf to paper or wax, by the help of her threads. And one of them was more elevated, another more depreffed; on the lower part where they refted on the down or mofs, they had contracted fome dirt or mouldinefs, by reafon of the dampnefs of the foil. I drew fome of the Worms that lay on the infide out of them and left others. And I found that thofe which I had left in their cells, were in fome days changed into Nymphs, and thefe afterwards in two or three weeks into Humble-Bees: thefe however did not creep out of their webs, but died in them, together with the Worms that I had drawn from thence. The eight cells of the other fide did not appear to be made of this waxy matter: their figure was likewife lefs regular and orderly, and I therefore imagine they were made by the Humble Bees themfelves; but as I thought that honey or Bee-bread might be found in them, I indeed greatly admired, when I found only Worms of various fize, and all clofed up. In each of two of thefe cells I found two large Worms *i*, and in another only one *k*, but this was much larger. Thefe Worms taken from thence and put into a cornet of paper, covered themfelves with a web of an oval figure, and in the mean time difcharged a large quantity of brown regular excrements, divided into equal parts, and very like the matter wherein they were depofited. In another cell I found a waxen partition *l*, and in one of the apartments thus feparated were two fmall Worms, and in the other two that were fomewhat larger. I likewife afterwards found in another cell three Worms *m*, and in another four *n*. From what has been here faid, it is fufficiently evident how greatly this cohabitation of the Humble Bees is different not only from that of the common Bees, but alfo from the nefts of the Hornets and Wafps, which are made by thefe infects themfelves, and are admirably conftructed. But what feems to me moft wonderful of all is, that thefe Worms of the Humble-Bees which fhould ftill be in a ftate of nourifhing, are really fealed up and covered with the waxy fubftance. Perhaps it may not be improper to conclude from hence, that thefe Worms ufe that matter wherein I found them covered, in the place of other food, and that the parent Humble Bees when the firft quantity is confumed, again lay another new parcel over them. This is in fome meafure the cafe in fome Worms, which being depofited in cheefe, flefh, fruit and plants, lie as it were covered up in their food or nourifhment; for thofe protuberances and knots, wherewith the whole infect is covered, rife in excrefcences, in plants and fruits, in the fame manner as the Worms in cheefe and flefh, at length intirely enclofe themfelves in thofe aliments. And hence it is very probable, that thefe Humble Bee Worms likewife feed on the wax wherewith they are covered and furrounded, nearly in the fame manner as the Wolf-Caterpillar ufes the wax for food, and fupports life: this I fhall hereafter defcribe in its place. Otherwife it would be neceffary that the Humble Bees fhould, in order to nourifh their Worms, continually open and again clofe up thefe cells, which would be a work of tedious and needlefs labour, fuch as cannot be any where found in the works of nature, which are every where perfectly fimple. The method of nourifhment I have fuppofed becomes more probable, if we confider the order in which the Humble Bees enclofe their eggs in this matter; for I do not think it poffible that the Humble Bees can fo exactly know the time when the Worms are to be excluded from the eggs, and when thefe cells fhould be opened, becaufe they may be in want of food. To this may be added, that the matter wherewith the eggs are covered, can fcarce be torn open any way without hurting them: but I fhall leave this matter in uncertainty, until repeated and more fuccefsful examinations determine it. That I may proceed in my intended ed method, I fhall obferve here, that I likewife faw an empty cell in this neft. This was likewife made of filaments or threads, and it feems to me probable that a young Humble Bee had crept out of it. At length I alfo broke thofe irregular particles of wax, which were in divers places found affixed to the woven cells of the Humble Bees: in one of thefe I found fix eggs, Tab. XXVI. fig. I. *d*, in a fecond feventeen *e*, and in the laft twenty-three *f*. Thefe eggs were pretty large, fomewhat crooked, and were faftened to the pointed extremity of the fubftance on which they were placed. When they were viewed with a microfcope, they appeared like that kind of rough skin which we call fhagreen. They were of a milk white colour, and full of moifture, and they all ftood erect and fo near each other, that they were almoft contiguous; this made a very beautiful appearance. I a long time preferved them as well within as out of the matter wherein they were enclofed, but they grew dry in the mean time, nor were any Worms hatched from them. Many Lice of unequal fize, and which are very tenacious of life, crawl upon the Humble Bees themfelves. I obferve alfo, that the Ants, and almoft all other infects, are tormented with their refpective Lice. Goedaert calls thefe Lice the Humble Bees excitatores or provokers, and has invented feveral amufing ftories concerning them, but he relates a fable rather than a true hiftory.

It is time we now defcribe the parts of the male Bee. I fhall here follow the fame method I obferved in the hiftory of the female, and fhall defcribe only thofe parts of the head, breaft and body, which either are not in the working Bee, or are feen plainer and more perfect in the male.

About the head are principally to be confidered the eyes, horns, teeth, and the feather-like hairs, wherewith the head is every where covered. I have already elfewhere treated of fome of thefe parts; therefore I fhall now defcribe the eyes, in which the following particulars are to be obferved on the in and outfide: the number of the eyes; the external figure; the hairs fixed on their upper part; the tunica cornea, and the uvea; the internal pyramidal and inverted fibres; the pulmonary tubes which run between thefe firft and fecond membranes, wherein the pyramidal fibres terminate; the tranfverfe cortical fibres, confpicuous under thefe membranes; the cortical fubftance of the brain, fituated under thofe fibres; the brain itfelf with the three fingular eyes over it; the origination of the fpinal marrow juft under it; the origins of the pulmonary tubes; and laftly, the internal furface of the eye.

As to the number of eyes, there are here two principal or large ones, one in each fide of the head; and befide thefe three fingular fmall eyes which are here in the male, Tab. XX. fig. I. *a*, in a triangular form between and below the larger eyes, in that part where thefe larger eyes are contiguous to, and again diverge from each other in form of the letter Y. In the females and working Bees, as has been obferved before, thefe three eyes are fituated higher up in the head, and lie pretty exactly between two larger eyes. But I fhall fay fomething more of this matter hereafter.

The two larger eyes refemble as it were a crefcent, with this difference, that in the upper on the head they are fharp-pointed, but fomewhat rounded *b b*; towards the lower parts *c* near the teeth, they again meet in a point. They are in form like a fegment cut from a flattifh rounded mafs, one fide whereof is fomewhat acute, and hollowed or bent inwards, and the other converges in a crooked form. In the upper part of the head toward the neck and back, thefe eyes are contiguous in their convex extuberant part, which is not the cafe in the two other kinds of Bees: but they again, on the lower part toward the teeth, where they become ftill more acute *c*, confiderably diverge from each other on each fide; the fmaller eyes, the horns, which are here fevered *f f*, the teeth as they are called, and fome feather-like hairs *d* being fituated in the intermediate fpace.

Both the eyes are alfo very thick covered with hair *e e e*, which, in order to avoid confufion, I here reprefent only on one fide. Thefe hairs ferve the eyes inftead of eye-brows or eye-lafhes; but becaufe their fituation cannot be exactly underftood, until after that coat of the eye which fupports them is defcribed, I fhall therefore now firft treat of that coat, the cornea, in which thefe hairs take root.

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The outmoſt coat of the Bee's eyes, is the cornea; by which name authors have likewiſe called this ſame tunic or coat of the eye in man, and in quadrupedes, birds, fiſhes, and ſerpents. This appellation is more particularly appropriated to this tunic, ſince by its ſtiffneſs, hardneſs, flexibility, and clearneſs, it approaches to the nature of horn. The eye of the Bee differs, however, from that of men and other animals, in that as the cornea appears in theſe ſmooth and equally poliſhed, it is in Bees and in all other inſects that I have examined, divided by various and manifold diviſions: and as theſe diviſions reſemble globules or little ſpheres, hence it is that ſome ſubtile and ſagacious geniuſes, among whom may be reckoned the illuſtrious Dr. Hooke, believed that the inſect's eye was only a congeries of innumerable little eyes, each of which, in reſpect to its ſtructure, agreed with our eyes and thoſe of other animals: this ſtructure of the eye, however, I have not hitherto ſeen in any inſect but in the Snail, which on one ſide exhibits two diſtinct eyes, furniſhed each with its three proper humours. In order to explain the diviſions of the cornea in Bees a little more accurately, I would have it obſerved that they are by no means ſpherical, but rather hexagonal, Tab. XX. fig. II. *k k*; but notwithſtanding this the maſſes themſelves are on the upper ſurface perfectly rounded, and conſequently exactly like the ſealed cells of the Bee; which being likewiſe circumſcribed by ſix ſides, yet riſe convex, and ſwell up in a globular ſurface, or are as it were arched. The woven cells of Hornets much more accurately expreſs this conſtruction of the cornea in the eye: for theſe have alſo ſix ſides, and are very beautifully encloſed in an arched or ſpheric web. The eye of the Bee, and moſt other perfect inſects, conſidered in this light, is really like a little net; which appears moſt perfectly when examined in the light by a microſcope: for then the moſt obſcure or opaque hexagonal interſections appear in the form of a net to any perſon who looks through the ſpherical tops of the diviſions. We muſt further obſerve here that theſe hexangular diviſions *k k* of the cornea, upon a more exact compariſon, do not perfectly keep the reſemblance of one of the cloſed up cells in the comb; for the lines which diſtinguiſh the cells of the comb from each other, are upright or ſtraight, whereas the hexagonal diviſions, on the contrary, which occur here in the Bee's eye, are intercepted by crooked and ſinuated lines. To obtain this form for them, the all-wiſe Author of nature makes uſe of the following means; that is, he gave the cornea a ſpherical convexity, by means of which ſome of the lines, together with their diviſions, are here and there broke off; and at the ſame time He alſo placed *k k* an hexagonal diviſion between ſix other diviſions of this kind: hence it is, that theſe hexangular diviſions appear as it were oval or arched, as I have in ſome ſort delineated between the annexed letters, Tab. XX. fig. I. *c, e e e, b b*. And in what manner every hexagonal diviſion is ſurrounded with ſix others, may be ſeen magnified under the letters *k k*, fig. II. Some curious perſons, to whom I ſhewed theſe, were of opinion, that in the ſtructure of the eyes reaſons might be found why the Bees make their cells hexagonal; that is, becauſe they exerciſe the ſenſe of viſion by hexagonal eyes. Behold, how far we are led away by fictions, when, being ignorant of the foundations of things, we follow our vain fancy as a guide! It would be as natural to ſay we ſhould build only round houſes, becauſe the pupil of our eyes is of that figure. I have not yet counted how many diviſions there are in the Bee's cornea, nor do I know any method of doing it, unleſs one could cut the cornea into ſmall pieces, and afterwards count the diviſions in them ſingly by the help of a microſcope; obſerving at the ſame time that every two of theſe cut diviſions are to be reputed only one. However this matter be, the accurate Dr. Hooke hath computed in the eye of the Perla of Mouffet, which he calls in his own language Dragon-Flies, but in the Dutch language Romboud, Puyſtebyter, Naeyer, and Glaſeſchryver, fourteen thouſand ſuch interſections; this is indeed a great number. To this we may add, that theſe diviſions are ſo beautiful, ſo regular, and formed with ſo much art, that it by many degrees ſurpaſſes the moſt exquiſite human workmanſhip. Indeed, could any one think this could be done by human powers? ſince we cannot ſeparate or divide thoſe things which nature formed only as it were in ſport. This is the external form of the more than ſtupendous cornea of the Bee's eye.

As to the internal ſtructure of the cornea, it is divided within juſt into ſo many hexagonal little holes, or as it were round ſpoons, as on the outſide it is geometrically diſtinguiſhed into hexagonal ſpheres. But if this cornea, turned to the light, be viewed with a good microſcope in the manner before deſcribed, then at length its true and delicate hexagonal reticulation may be finely obſerved: for as the cornea is very pellucid and thin where it is hollowed or excavated into theſe little ſpheres, but conſiderably thicker where it is interſected; hence it happens, that the interſections only ſeem to ſhew themſelves to a perſon who looks through them: and this is the true reaſon why the cornea then exhibits itſelf like a net pierced by ſmall hexagonal apertures. But its ſurface is not always the ſame; ſometimes it appears divided into triangular, and ſometimes into quadrangular figures: this diverſity muſt be attributed to the variety of reflexions which the rays of light occaſionally produce in their paſſage. This obtains principally when the angles of the diviſions of the cornea are not all directly under the microſcope,

ſcope, for then only one part of the convexities can be ſeen, and the other not at all; and thus falſe angles are exhibited. Almoſt all concave bodies, if viewed in the light, appear to our ſight ſometimes globular, and ſometimes roundiſh and convex: this is illuſtrated very particularly by the engraved agats. For this reaſon the greateſt circumſpection muſt be always uſed in viewing objects by microſcopes, leſt we ſhould deceive ourſelves, which has commonly happened on theſe occaſions. I ſhall hereafter explain what produces theſe hexangular diviſions in this net of the eye. The thickneſs of the cornea in the Bee is pretty conſiderable, and indeed more ſo, conſidering its ſize, than in many other inſects which are equally ſmall: this may in ſome meaſure be comprehended from a ſmall piece of it delineated as it appears under the microſcope at the letters *lll*, Tab. XX. fig. III. Between the diviſions we have been hitherto deſcribing, are placed thoſe hairs which I have before ſaid are planted all over the eye. They are very firmly fixed to the cornea, for they pierce it all through in the ſame manner as our hair does skin: but they riſe ſharp-pointed, and are three or four times longer than the diameter of any one hexagonal diviſion: in ſtructure they reſemble briſtles, and are of a round figure, thick below and ſharp above. Their number is likewiſe very conſiderable, though leſs than the number of the diviſions; they are, however, ſo thick and ſo cloſe ſet together, that they ſeem to conſtitute a very cloſe foreſt of briſtles, like ſo many fir-trees planted upon the eye: this may be ſeen in ſome meaſure under the letters *eee*, fig. I. where I have repreſented them only in the circumference of the diviſions of the eye: of the other diviſions that are exhibited in the ſame figure, I have delineated a leſs and determinate number, they being very numerous, and hitherto beyond any account I have taken. Finally, I ſhould think theſe hairs are principally fixed here to guard the eye againſt any thing falling on, or ſtriking againſt it; to keep off the duſt, and, in caſe any of theſe annoyances ſhould ſlip in, to aſſiſt the Bees to throw, or bruſh it out the more eaſily, by a friction, which the Bees perform with their feathered legs: Flies alſo uſe the ſame method to wipe themſelves. Theſe hairs ſeem alſo to ſerve the Bees inſtead of eye-brows or eye-laſhes. I had firſt thought that only the long-lived ſpecies of inſects, ſuch as Bees, had theſe hairs: but I afterwards obſerved that they are not ſo peculiar to the Bees, as not to be found in many other ſpecies of inſects. I have found them among others in the coloured diurnal Butterfly: I have likewiſe found them on the eye of Goedaert his Bee. This eye, however, is not covered all round with theſe hairs, but only ſhews the oval orbit planted with them. Goedaert deſcribes the Bee I have juſt mentioned, in the ſecond experiment in his firſt part; but if any one examines this more accurately, he will find it is only a dunghill Fly, with no more than two wings, and conſtantly produced or generated annually in the ſame manner. It is produced from a Worm with a long tail and very ſhort legs, found in dunghills and common-ſhores, and belongs to the fourth order of our natural tranſmutations. The Bee, on the contrary, is to be ranked in the third order, as I have already ſufficiently proved. I ſhall proceed to deſcribe the uvea, which is the other coat of the Bee's eye. Of the other three remarkable little eyes I ſhall treat at large hereafter.

When the cornea is removed from the internal parts of the eye, the tunica or coat, underſtood to be the uvea, comes in view. This, therefore, is not placed in inſects at the bottom of the eye, but next to the ſurface; nor does it any where appear perforated as in large animals. This conſequently prevents the rays of light penetrating further into the eye than through the cornea only. When the cornea is taken from the eye, we uſually ſee that a more opaque matter, which entirely takes away the perſpicuity or clearneſs of the cornea, is carried off with it. This matter is of different colours in different animals; in Bees it is of a deep purple, in other inſects it is green, in ſome blue, in others black, and in others again it has a very beautiful mixture of various colours, which are elegantly and agreeably ſeen through the cornea. But this is to be found only in the inner ſurface of the cornea, where the uvea adheres next that coat, without any thing between. The two parts of this matter which conſtitutes the uvea, both that which is applied to the inner cavity of the cornea, and that alſo which is obſerved to adhere to the internal parts of the eye, are commonly of a blackiſh colour, and the laſt likewiſe ſtains the fingers when touched, and is a kind of black paint, as our uvea and that of other animals is: and hence it ariſes, as I have before obſerved, that the perſpicuity of the cornea is darkened or obſcured by this matter. Therefore, in order to ſhew the cornea pellucid, this matter muſt be firſt wiped off with the help of a pencil or a ſmall piece of paper folded up. If you preſs the head of the Fly between two folds of paper, the paper acquires a purple colour from it, which is owing to the more diffuſed colour of the uvea. But perhaps ſome one will aſk, if the matter hitherto deſcribed ſeems only to be the uvea, but is not ſo in reality, what is it? To this I anſwer, that this matter is nothing but the tops of ſome broken fibres, which are placed cloſe under the cornea, Tab. XX. fig. I. *gg*: for no humours, properly ſo called, are found in any part of the Bee's eye, which is a thing well worth obſerving: though the celebrated Dr. Hooke, for want of a ſufficient number of experiments, hath been led to imagine there were ſuch in the eye of the Libella; becauſe no other method occurred

to

to him, by which the ſight of inſects could be explained. However this matter be, the coloured part of the Bee's eye, though it be not an uvea, ſerves the uſe of that coat in the eyes of larger animals.

Immediately then under this uvea, as it has been called, are ſeen ſo many fibres, as there are diviſions above in the cornea. Theſe fibres very exactly agree with the cavities of the ſpherical diviſions of the cornea: and they are likewiſe hexagonal and broad, but thiner in the middle and ſharp-pointed underneath where they terminate. They are all nearly of equal length, thickneſs, and breadth. But above the margins and extreme ſinews of the eye, theſe fibres are ſomewhat bent and ſeem ſhorter: they are above, where they are joined to the diviſions of the cornea, much thicker *h h* than below *i*, where they are only united together by their ends: and hence they almoſt reſemble ſo many inverted ſexangular pyramids, thick and broad above, and thin and acute below. In order to conſtitute the convexity or arch of the eye, they are placed together in the manner of thoſe eggs of inſects which are circularly glued round the branches of trees. Theſe fibres ſtand erect on the bottom of the eye, in the ſame manner as the hairy filaments lie under the leaves of an artichoke on its disk or receptacle. I have above deſcribed the colour of theſe fibres; I ſhall only obſerve further, that this paint, with which their larger extremities are tinged, is likewiſe diffuſed deeper downward: and the other parts of theſe inward fibres are, as I have ſaid before, tinged with a red or purpliſh colour. Thoſe fibres which ſtand in the middle of the eye are ſtraight *h h*; but thoſe that are on the ſides appear ſomewhat oblique, and the reſt run a little crooked alſo; but all terminate in a ſubjacent membrane, with which they are naturally united, but from which they are eaſily broken off when handled. This membrane, therefore, very finely exhibits almoſt the ſame diviſions in dotted figures, which the omnipotent Creator hath been plaſed to make on the cornea *c b b*, with ſuch ſtupendous and inimitable art. Concerning theſe fibres we are further to obſerve, that if the cornea be ſeparated from, without hurting or breaking them, they very beautifully repreſent the hexangular diviſions of the combs: but when the cornea is pulled off in ſuch a manner as that ſome particles of theſe fibres adhere to it, then their figure is not ſo diſtinguiſhable. Theſe fibres are very eaſily broken, when the cornea is ſeparating from them; for they are connected with the cornea, and are received into its cavities: but this union is rendered ſtronger by means of innumerable pulmonary tubes, which aſcend near thoſe fibres towards the cornea, and, as I think, conſtitute its hexagonal diviſions: nay, they likewiſe probably contribute to expand the eyes at the time when they are caſting their ſkin, and are very ſoft and tender, by force of the air impelled within. Hence near the diviſions of the eyes, the pulmonary tubes will have the ſame uſe and ſituation as I have before attributed to the ſame tubes, in regard to the wings of Bees. I would not, however, have my opinion in this caſe conſidered farther than as a probable conjecture. One of theſe fibres is likewiſe united with another immediately under the cornea; and a little lower ſome cluſterings and knots are obſerved among theſe fibres. But where theſe fibres are broken off, when the cornea is not regularly taken from them, their full purple colour, as hath been ſaid above, is found not to terminate there, but deſcends deeper. It is indeed very wonderful, in what manner and in what numbers theſe pulmonary tubes aſcend near theſe fibres, and are united together. I muſt own that I ſhould be very glad to examine, of what nature theſe fibres are, whether muſcular or nervous; as alſo whether or not they have any motion, and of what kind of particles they are compoſed: but it has been abſolutely impoſſible for me to examine all theſe things, for both my ſight and inſtruments failed me. However, I have again ſeen the Creator conſpicuous with human eyes in this ſtupendous conſtitution of the moſt admirable and unſearchable little parts, which exhibit, as it were engraved thereon, the real image of his inexhauſtible power and wiſdom.

That I may proceed in the order wherein I began, I ſhall now deſcribe that part, Tab. XX. fig. v. *x*, towards which all the fibres hitherto mentioned converge, as towards a common center, and to which they are united, as the threads of velvet with their web; this part is white and fibrous, and is ſituated within the eye: but the pulmonary tubes before deſcribed aſcend through and on each ſide of it towards the fibres. The figure of this membrane is exactly like the external figure of the eye, one ſide of it being lunar or like a creſcent, and the other ſemicircular. It is white in the middle, but in the border it partakes ſomewhat of the colour of the ſuperior or upper part of the fibres, the impreſſions of which are ſeen thereon.

This membrane, being removed from its place by the help of a fine inſtrument, there appears cloſe under it another membrane, much more delicate and tender, as alſo clearer: and this, by means of pulmonary tubes, is connected, though not very ſtrongly, with the former.

There is placed under or behind this membrane, but a little lower or deeper in the eye, another or ſecond ſpecies of fibres, fig. IV. *n n n*, and fig. v. *q q*, which being tranſverſely applied to the lower ſurface of the membranes, are like ſo many beams or tranſoms, which ſupport the pyramidal fibres laid over them. Theſe alſo differ from the former pyramidal fibres, both becauſe they are fewer in number, and by far leſs delicate; though notwithſtanding their thicknefs I could not eafily divide them. Some of thefe fibres are laid over others, Tab. XX. fig. IV. *o*, in the fame manner as they are wont here at Amfterdam to pack beams or pieces of timber on board of fhips to be exported; that is, they were here and and there feparated from each other, and fpaces were left between them; and by this means was exhibited an object, like the courfe of the mufcular fibres in the papillæ of the kidneys. Thefe things appear more beautifully when the diffection of the eye is begun in the lower part, as may be feen fig. V. under the letters *q q*, which reprefent the fame fibres. Of what nature thefe fibres are, and whether they communicate with the brain *s s*, I have very anxioufly inveftigated, and, if I am not miftaken, I have found that they are joined to the brain, nay, they are of the fame colour with the brain, that is, fomewhat grayifh in part, and elfewhere frefh coloured: hence I call them the cortical fibres, becaufe they are like the cortical fubftance of the brain. In the Wray-fifh, there is feen a very remarkable nerve, iffuing out of the brain, and terminating in a large inflated extremity. This is conveyed towards the bone of the head, and is there admirably divided on each fide into many filaments, to which thofe fibres in the Bee's head likewife anfwer, and it may in fome meafure be likened; though thefe nerves in the Wray-fifh do not all feem to contribute to the fenfe of feeing, but rather to that of hearing or fmelling: this matter therefore ftill remains to be inquired into.

Between thefe fibres is feen the cortical fubftance of the brain, the nature of which thefe fibres do not feem to be unlike. It is manifeft that this fubftance *s s*, as well as the matter of the fibres *q q*, remarkably communicate with the brain, indeed that they both rife out of it.

The brain of Bees confifts of four pair of diftinctly confpicuous parts, to which, as a fifth may be added, namely, the fpinal marrow within the fkull, or the principle or origin of thefe little parts *r*; nor can I befides thefe find any others in this infect, not even the fo famous pineal gland *. The two foremoft of thefe little parts, fig. VI. *c*, are fomewhat globular or pyriform, and emit two nerves on each fide, which are divided again into two parts *d d*, but their courfe, or the way they are fent off, is ftill a fecret to me. The other three pair of little parts I have not yet fo plainly difcovered, as the firft here defcribed, becaufe they communicate and are connected with the three particular little eyes before mentioned, which are placed in a triangular form, fig. I. between the larger eyes here explained, and divided in the manner juft laid down, though I could not fo diftinctly as I could have wifhed explain the method whereby this connexion and communication are performed. The firft thing that I have obferved diftinctly with regard to thefe little eyes, is that they alfo have pellucid cornea; and fecondly, that in their cavity there likewife appears a coloured little part, which may be called the uvea. But of what nature this fubftance, which is under the uvea, is, and whether it likewife confifts of numerous fibres, or is itfelf a fingle fibre, I cannot determine, though it feems to me to be a continued fubftance. Thirdly, below this we fee thofe three pair of little parts, which are as it were enclofed within it: thefe are the reafons why I call thefe parts eyes. To which may be added, that the eyes of Spiders and Scorpions are externally formed exactly in the fame manner, and are fmooth, glittering, and without divifions, and they are difperfed as thofe that are difpofed at random over the body. The Wolf Spider, which catches its prey by leaping on it, and not by means of webs, has its eyes placed in the fame manner. But this fpecies has a very exquifite and incredible fharp fight, compared with other Spiders, which feem almoft blind and, as it were, deftitute of motion, that they may catch their prey, if any falls into their fnare, with greater certainty. I have not yet difcovered the internal ftructure of thefe three eyes of the Bee. The letter *b*, fig. VI. likewife fhews the brain, or rather one pair of thofe parts of the brain. We have before defcribed and explained by what means the cortical fubftance of the brain, is fhewn when the fibres are taken from it. The letters *e e* feverally fhew the third and fourth pair of little parts, or the cerebellum, and alfo the manner wherein thefe parts communicate with each other. The cortical fibres, fig. IV. *n n* that iffue from thefe, are reprefented in their fituation in the fourth figure. In order to obferve the principle or beginning of the fpinal marrow, fig. V. *r*, it is neceffary to begin the diffection of the eye at the loweft part, or where the head is joined to the thorax. But then if you only remove the horny head, you will immediately fee the fat, and the originations of the pulmonary tubes, which are here very numerous, and the larger branches of which are diftributed towards the upper parts; but the fmaller are connected with the fat, in the fame manner as the fcapus or ftalk of a bunch of grapes is with its berries, and hence is produced a moft agreeable fight: one or two membranes alfo muft be there feparated from the brain, before the marrow comes in fight. But then one may fee there very beautifully that other fpecies of the fibres of the eye, Tab. XX. fig. V. *q q*, which I have called the cortical fibres, and reprefented under the letters fig. IV. *n n n*, in

* The Bees have probably all that delicacy of fmell, for which they are celebrated; but it is not true that they diftinguifh perfumes by their fondnefs, and ftinks by their averfion: certain fmells excite and others offend them; but their notions of fweet and ftink are not the fame with ours. They are fond of places where urine ftands to putrefy, than which there is fcarce any fmell more offenfive. It had been faid they would fly in fondnefs to a man who had a nofegay of fweets about him, and that they would fting any who carried ftinks; but Mr. Reaumur made the experiment and found it falfe. There are wonders enough in the real hiftory of thefe animals; 'tis wrong to difgrace them with falfe and fictitious tales to make all fufpected.

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the preceding figure of the eye, the diffection of which was begun at the upper part: then, at the fame time, may be very beautifully feen alfo the inferior or internal furface of the cortical fubftance of the brain, fig. v. *ff*, which partly covers thefe cortical fibres. This cortical fubftance likewife feems to be here divided in the middle, which divifion is covered with a kind of thin membrane. This little part and its divifions I have marked with the letters *a a* in the fixth figure, which exhibits the fection in the upper part. The marrow, fig. v. *r*, as hath been obferved, appears then very beautifully placed between the cortical fubftance of the brain; and at the fame time it may be feen how it partly communicates and is connected with that cortical fubftance. But I fhall afterwards particularly delineate, to the glory of the great Creator, and defcribe the whole marrow with all its nerves. I fhall only obferve here, that the letter *y*, fig. I. and v. exhibits the firft knot which the marrow forms out of the brain; but fo, that in one figure it is placed above, in the other below. Fig. v. *z z*, are the pyramidal fibres of the eye, deprived only of their cornea on each fide. *u u* Exprefs the thickeft part of the fibres, and the place where they are moft coloured. *x* Shews the internal coat of the eyes, before demonftrated under the letter *i* fig. I. in which the pyramidal figures terminate.

Here alfo about the lower verge of the head fome parts of the mouth are feen, together with the two horny prominent little parts, wherein the mufcles of the teeth or jaws are in part fixed, and alfo the mufcles belonging to the beginning of the œfophagus. But I pafs by all thefe things at prefent, nor fhall I attempt to defcribe the organs of hearing, or thofe of fmelling, as I have not been hitherto able to obferve any veftiges of fuch; though I fhould fcarce believe, that the all-powerful Creator, who hath given to the Bees the organs of fight fo wonderfully formed, fhould deny them organs for the other fenfes. But fo great is our weaknefs, that we are not able to comprehend and underftand natural things.

It is likewife very difficult and hard to find the organs now mentioned in fifhes and many other animals, becaufe they have no external paffage or opening. Thus I have obferved in the Chameleon, that the aperture of the organ of hearing opens into the mouth; which is likewife the cafe in the Frog. And hence it neceffarily follows that the knowledge of the ftructure of one animal throws a light on, and fhews us the way to that of another. Indeed, comparative anatomy is a moft faithful and liberal miftrefs, fince the parts that are obfcure and hard to be feen in one animal, may be fometimes very diftinctly traced in another. Before I difmifs the eyes, I fhall firft briefly fubjoin here what I have feen and obferved about thofe of fome other infects.

The eyes we have been hitherto defcribing are formed in like manner in the working Bee: there is however this difference that in the latter they are vaftly fmaller, and therefore have the fewer number of inward fibres. But to proceed in order, I fhall here obferve, that if the skull, together with the cornea of thefe three little eyes, be taken off the head at the fame time, then immediately between thefe eyes, and under the antennæ or horns, are obferved two oblong pulmonary bladders, which I have not feen in the head of the male, and which probably make the working Bee light, and give it a greater agility. There is a larger quantity of fat in the head of the working Bee than in that of the male. This fat being placed on a piece of very thin glafs, and left fo until it is dried, becomes entirely pellucid, becaufe its tender connecting white membranes grow dry by this means, and hence alfo the pulmonary tubes diftributed through this fat now become confpicuous. This fat adheres in a wonderful manner, linked as it were, and twifted under the skull; the mufcular fibres of the jaws are alfo here more numerous than in the head of the male. But the brain, the tranfverfe cortical or gray fibres, and the cortical fubftance of the brain itfelf, are here conftituted in like manner as in the head of the male Bee, but they are clearer and more eafily examined; for the inverted pyramidal fibres fituated above are fewer in the working Bee, and do not all prevent the fubjacent parts being feen.

The eyes of the Wafp are conftructed nearly in the fame manner, and in their external and internal form refemble the Turkifh kidney-beans, being bent fomewhat inwardly towards the fides of the horns or antennæ, as if there was fome part cut off there. The internal fibres anfwer to the external divifions, as before obferved; for as the pyramidal fibre is extended by every divifion, it neceffarily follows, that the internal figure of the eye is entirely like the external.

In many fpecies of infects there is a confiderable and wonderful difference in refpect to the external figure of the eye. How the eye of the Rhinoceros Beetle is difpofed and fafhioned, is fhown by its figure.

In the Bee of Goedaert, which is really a dunghill Fly, the eye is framed nearly in the fame manner as in the working Bee; for under the divifions of its cornea, there are likewife placed a great number of pyramidal inverted fibres, which being broken off with the cornea, a very beautiful red or fomewhat purplifh matter prefents itfelf; but when the cornea is removed from the pyramidal fibres without hurting them, they appear yellowifh. There are likewife innumerable pulmonary tubes in this eye, and a great quantity of fat.

In the Libella, or Fly of Dr. Hooke, called by the Englifh the Dragon-Fly, and in Dutch Puyftebyter and Rombout, the eye, in refpect to its external divifions and internal pyramidal fibres, differs confiderably from the eye of the Bee; for the upper divifions are much larger

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in it, than the lower, and the internal pyramidal inverted fibres, which anſwer to the upper diviſions, are in the ſame manner much larger than thoſe which are connected with the lower. The colour of the larger pyramidal fibres is purpliſh, but the ſmaller are duſky or blackiſh. It would indeed be worth while to ſpend ſome time in the examination of this eye, becauſe a very large aſſortment of theſe fibres is diſtinctly viſible in it, and may be conveniently enough managed; beſides that in the hexangular diviſions of theſe fibres, which are received into the cavities of the cornea, ſome myſteries ſeem to be ſtill hidden. I hope I ſhall be able to inveſtigate them at ſome other time, when I ſhall enter into a more exact examination of the many obſervations that I have hitherto propoſed; for the attentive ſpirit that is neceſſary in ſuch a number of things as are treated of therein, muſt at times relax and grow languid; and therefore I ſhall not deny but that I may probably be in ſome things deceived.

Some one may here object that the parts hitherto deſcribed are not eyes, but ſurely nothing is more plain and evident. The juſtly celebrated Hooke made ſeveral experiments to prove this: among others he wounded theſe eyes and cut off a part of them, by which means the creatures loſt their ſight entirely. This experiment may be made with little trouble; and whereas the wound and pain occaſion ſome change about the ſight, nothing more is neceſſary but to cover theſe eyes with a little black paint mixed with oil, with a pencil, by this means theſe inſects become blind, and by all their actions immediately ſhew a perfect defect of ſight. This experiment may be beſt made on thoſe Flies, the eyes whereof have no hairs, and therefore may be eaſily coloured. It is wonderful to ſee how tame and gentle the Fly becomes when its eyes are thus covered with paint; it ſuffers itſelf to be caught every moment, and when it runs or flies, you will ſee it ſtumbling everywhere, and when this happens it is driven back, like a ball, by whatever oppoſes it; unleſs it ſhould perhaps fix itſelf quick enough by the help of its claws, and thus avoid falling, as I have ſometimes obſerved.

This is the ſtructure of the Bee's eye, and of the eye of other inſects in general. The famous Dr. Hooke hath endeavoured to exhibit a magnified figure of ſuch an eye, deſigned from the Libella in the twenty-third and twenty-fourth plates of his juſtly celebrated micrography. It will be now asked by what means is the ſenſe of viſion performed in Bees and other inſects? I anſwer, that the conſtruction of the eye ſhews clearer than the light at noon, that viſion is not performed in it, as it is in us, and many other animals, by collecting the rays of light, which paſſing through the pupil fall upon the retina; but merely by the contact of theſe inverted pyramidal fibres, formed by the light propelled through the cornea. Theſe eyes are ſo diſpoſed as to receive the appearances of things by the ſimple appulſe of the reflected light: and this method of ſenſation cannot but be very lively. But as the pupil is never in theſe creatures contracted as it is in us, nor hath any foramen or aperture, hence it follows that the ſenſe of ſeeing muſt be very perfect in inſects, on account of the great number of rays which conſtantly fall on their eyes. And hence it likewiſe is, that many inſects ſee in the night: the Dragon-Fly, therefore, from the ſame cauſe, very quickly catches its prey flying. The organs of ſight, which inſects poſſeſs, can by no means be compared with our eyes, or with the camera obſcura, formed upon their principle, in which the appearances of things are by the help of reflexion painted on a paper or white cloth. On this occaſion I cannot but inſert an incident, which the illuſtrious and incomparable Boyle, in his treatiſe of colours, relates of a blind perſon, who, by diſtinguiſhing the roughneſs of coloured ſubſtances, could accurately diſtinguiſh their ſeveral colours by his fingers. This method of ſeeing, if it may be ſo called, being performed by touching, is in ſome meaſure like that which obtains in the eyes of inſects. But how this viſion is really performed in inſects, and by what means that great number of pyramidal fibres are excited by the light falling on them, as alſo how this motion is communicated to the ſubjacent reticulated membranes, and from them afterwards is conveyed to the tranſverſe fibres underneath; and from theſe again to the cortical ſubſtance of the brain; from the latter to the nerves and at length to the origination of the marrow or brain, no perſon can explain: this can be known only to the all-ſeeing Creator of the univerſe. He alone can tell whether viſible appearances or objects in inſects are ſtopt on the uvea or not. It is enough for me to confeſs my own weakneſs, and, after explaining the conſtruction of this eye, to proclaim aloud the praiſes of the ſupreme Architect, I muſt likewiſe acknowledge that I began theſe obſervations with the greateſt pleaſure at the end of September in this year 1673, and that they gave me more delight than if I had ſeveral hundreds years added to my life. I hope that this matter will ſhew the omnipotence and unlimited power of God, and inflame with the moſt ardent love towards their Creator, thoſe frozen ſouls, which ſtill deny the divine providence in reſpect to theſe little creatures. Indeed if we could accompliſh this with our labours, it ought to give us the greateſt joy, for it is for this purpoſe only and not to trifle away time, or acquire immortal fame or glory, that we ought diligently to inveſtigate the works of God.

I likewiſe ſaw at the ſame time, that each of the antennæ or horns, where they are articulated with the head, have three or four diſtinct muſcles, by the help of which they can be moved various ways, and may therefore both aſſiſt the ſight and defend the eyes from injury and any thing ſtriking againſt them. I have not attempted to diſcover the muſcles of the other joints, whereof the antennæ or horns conſiſt;

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for they are so minute that neither the eyes, the hands, nor the underſtanding of man, nor our inſtruments we uſe can examine them juſtly. The ſame muſt be acknowledged of the muſcular fibres of the jaws or teeth, ſince we are incapable of diſcovering their excellent conſtruction and beauty, or of juſtly deſcribing or delineating them. I ſhall, however, ſay ſomething of the feather-like hairs of the head of the Bee, when I treat of thoſe of the thorax; which I ſhall now proceed to deſcribe.

The external figure of the thorax is in the upper part convex, but towards the hinder parts it is ſinuated, and is adorned with a ſomewhat prominent margin about its extremity. On each ſide of the anterior part there appear the ſcapulæ or ſhoulder-blades, by which the wings are joined: a little lower on each ſide under the wings and ſcapulæ are ſeen the points of reſpiration; whereof the orifices are oval, and ſurrounded with a horny margin. The under face of the breaſt is divided into two parts, which are ſtretched ſomewhat obliquely and bent downwards, and give inſertion to the laſt pair of legs joined to the lower edge, as the firſt pair of legs are articulated with the fore parts of the breaſt: theſe, when the head is drawn from the trunk of the body, adhere to the head, and are pulled off with it. The breaſt is of a horny or bony ſubſtance, and is thick ſet above, below, and on the ſides with feather-like hairs, which are of equal ſize and length in the upper region of the breaſt. Theſe hairs, which are diſtributed over the whole ſurface of the body, and are found even in the head of the common or working Bee, as alſo between and under the horns of the males, are all of them, as hath been ſaid before, perfectly like downy feathers, and particularly like the down of Swans, or thoſe remarkable hairy feathers conſpicuous in the tails of Peacocks; the middle ſtalk of which feathers is ſurrounded with many ſcattered lateral hairs.

Before I proceed to the diſſection of the internal parts, I muſt repeat again that Bees produce their humming noiſe with their wings only: ſince the ſmall, membranous, moveable wings at the ſhoulders, may eaſily produce ſuch a noiſe, by means of the air propelled from the ſubjacent pulmonary tubes: for no points of reſpiration open into the mouth, which is to be well obſerved: to this may be added, that the narrowneſs of the trunk is not adapted for modulating the air; if any of the latter ſhould be impelled thither out of the ſtomach, in which indeed I have found air. The wings of Flies are wonderfully formed in that part where they make this noiſe; though this ſtructure is very different in the various kinds, Some Locuſts indeed make a noiſe by the ruſhing together of the wings; and for this purpoſe nature has given them near the hinder part of the wing towards the breaſt a ſingular ſmall part, which, when moved, forms a diſtinct ſound like a thin plate of metal. Other ſpecies of Locuſts make a noiſe by rubbing their wings againſt their legs. Crickets and Mole-Crickets modulate the air in ſuch a manner by the help of their wings, that the chirping noiſe they make is produced from thence. The Graſshopper has two peculiar ſmall drums, like the drum of our ear, which, being ſtruck by the help of two lunated cartilages, vibrate the air in ſuch a manner as to produce that ſound. Beetles make a noiſe by rubbing the horny parts of their head againſt the articulations of the breaſt, and the parts about the tail with the caſes of their wings. All the inſects to which nature gave ſingular organs for making a noiſe are of the male ſex: this may be ſeen diſtinctly in the Locuſts, Graſshoppers, and others, the females of which make no noiſe. In regard to the wings of Bees, we may obſerve they are here and there briſtly, and that the veins and nerves conſpicuous in them, are only ſcattered pulmonary tubes, by the help of which, as we have before expreſſed in words and figures, the wings are for the moſt part diſpanded.

The contents of the thorax are various: they are the moving fibres of the legs and wings, and alſo ſome which are deſigned for moving the abdomen, and others for moving the neck. Theſe muſcular fibres fill almoſt the whole thorax. The other parts to be found there are the pulmonary tubes, ſome fat, the gullet, and the ſpinal marrow: all theſe I ſhall now paſs by, and only ſay ſomething of the muſcular fibres, and ſhall then proceed to the contents of the belly. On this occaſion I ſhall give a deſcription of the ſpinal marrow. The muſcular fibres of the breaſt, as we have already related, fill its whole cavity, and may be divided eaſily into thoſe which move the fore, middle, and the hinder legs, and into thoſe which ſerve to move the wings: for where theſe parts are ſituated, there are ſeen the tendons of thoſe fibres, which are afterwards expanded and fleſhy in the thorax, and afterwards becoming tendinous, above in the upper region of the breaſt, are there fixed as it were into an horny little part. The fibres which are implanted in the middle of the thorax ſtand almoſt perpendicular, but thoſe which are inſerted ſomewhat lower towards the ſides, are more oblique; and thoſe that are in the anterior part united to the legs, run entirely oblique and are almoſt flat. Where the muſcles are fixed to the wings, there is a kind of diſtinct articulation, beſides that by the help of which the greateſt motion of the wings is performed. If the fibres of the thorax are ſeparated from each other, they divide into oblong hairs, as it were, which are connected with delicate, white, nervous, and tranſverſe fibrillæ, and are at length here divided ſo minutely, that I muſt deſiſt from further ſearch; being filled, as before, with admiration of the divine Architect, who here in a ſmall fibre manifeſts to me his omnipotence and my weakneſs. For to this purpoſe only, and that we may terminate our greateſt deſires and ſtrength in him and in his pleaſure, all his works are offered to our contemplation. When I opened the margin or verge beforementioned, and which is viſible in the hinder extremity of the thorax, it appears full only of pulmonary tubes and fat.

The parts contained in the abdomen of the male are indeed as admirable as thoſe which I have before explained as ſituated in that part of the working Bee and of the female. But as no difference occurs here in regard to the ſtomach, inteſtines, and other parts, I ſhall deſcribe only the organs of generation in the male: for thus the difference between this male and the female, which has an ovary, and alſo between that and the working Bee, which is not furniſhed with either male or female organs, will be more evident. After this a ſhort deſcription of the ſpinal marrow ſhall conclude the whole of this diſſection. Though this ſpinal marrow be formed alike in each of the three kinds of Bees, yet I chuſe rather to deſcribe it particularly in the male than in the working Bee, becauſe the male has a larger body.

The genital organs of the male are extremely large and very eaſily viſible; for they poſſeſs the whole abdomen, nay, the abdomen of the males ſeem to be larger than that of other Bees, that it may be capable of containing them. This will be teſtified by the moſt ſerene duke of Tuſcany, Coſmus III. who in the year 1668, in company with the illuſtrious Mr. Thevenot, vouchſafed to view at my houſe, with great admiration at the ſupreme Creator, theſe parts in the Bee, and graciouſly to honour my labours by this unmerited viſit. The genitals of the male Bee, if we conſider the ſmallneſs of the whole inſect, by far ſurpaſs, with reſpect to the quantity of ſperm, thoſe of all other animals whatſoever. That ſeed is contained chiefly in the ſeminal veſicles or bladders, as is the caſe in other inſects, and in larger animals, as Moles, Hedge-hogs, and Rats, which, as they are ſwelled with abundance of ſperm, have greater plenty of it collected in theſe bladders than in their teſticles. I could almoſt ſay that it is ſo in man likewiſe; for when I compare the narrowneſs of the filament or veſſel of the teſticle with the capacity of the ſeminal bladders, and at the ſame time conſider the quantity of the ſeminal matter, generated in the veſicles themſelves, that it is not transferred thither, according to the common opinion, out of the teſticles. But to proceed; we muſt accurately obſerve, that the parts which contribute to generation, and alſo to exclude or expel the ſperm are the following: two teſticles, Tab. XXI. fig. I. *a a*; two vaſa deferentia *b b*; theſe are diſtended *c c* on each ſide to a larger and more remarkable ſize than the teſticles themſelves: the two ſeminal bladders or veſicles *d d*, of a ſtupendous bulk; the root of the penis *ee*; a very conſiderable horny little part which is placed *f* ſomewhat towards the anterior end in the thickeſt part of the root of the penis; the penis itſelf, or the part analogous to it or like it *g*; another little part of a bright red colour diſtinguiſhed *h* by five diviſions; and under it, on the other ſide, another but larger pyramidal little part *i*: laſtly, there are the two pointed *k k* yellow appendages of the pudendum, with red ends, and inveſted with a very thin ſkin, which contain this ruddy colour, and when wounded readily diſcharges it. The little figure marked fig. II. *o* repreſents all the parts hitherto recited in their natural ſize. The teſticles, fig. I. *a a* are placed in the upper region of the abdomen, and ſituated as it were at the back or loins; as is the caſe in Birds, Frogs, and other animals. They ſeem to me to conſiſt of tubes, as in the water Beetle, the genitals of which I ſhall hereafter delineate. Innumerable pulmonary tubes are likewiſe inſerted into the teſticles, which greatly prevent the ſtructure of the latter from being inveſtigated according to one's wiſhes. Theſe are of a pale citron colour with a tinge of purple, which is likewiſe the caſe in Silkworms. The vaſa deferentia *b b* are very ſmall, ſlender, and delicate in their ſtructure, and appear whitiſh on account of the ſperm which ſhews itſelf through them: they are twiſted like the tendrils of a vine; nor do they appear to the obſerver until after the pulmonary tubes, which join together their knots and convolutions, are gently and by degrees cut off with great care and very tedious labour. Theſe pipes are ſo ſtrongly connected with the winding of the vaſa deferentia, and with that part of them which becomes broader, and alſo with the teſticles themſelves, that they ſeem to conſtitute as it were one body with all theſe parts. The vaſa deferentia are here, as they are in man and brute animals, joined by one extremity to the teſticles: a little further examination ſhews very plain, how theſe vaſa deferentia are dilated, and reſemble as well in reſpect to their colour as the inſerted pulmonary tubes, ſecondary, or other teſticles. But being more accurately examined, they diſcover within a conſiderable cavity, which the teſticles have not. They are likewiſe of a glandular ſtructure, and are diſtended with a ſeminal matter, which immediately flows out of them when wounded. Before theſe veſſels are connected with the root of the penis and open into its cavity, they are a ſecond time contracted in a remarkable manner, and appear only ſimple tubes, or ſmall ſeminal veſſels: they are at length inſerted by their other extreme into the lower part of the ſpermatic bladders. I think that in this dilatation *c c* of theſe veſſels, a ſeminal matter is certainly ſecreted; and in like manner I do not doubt but the ſame happens in man, where the vaſa deferentia are dilated into the form of bladders.

Next

Next the vaſa deferentia are placed the ſeminal veſicles *d d*; theſe are wonderfully large, and are full of ſeminal matter; they are whiter than ſnow, and are of a very fine texture. They ſeem, indeed, to be of a glandular conſtruction, only that the muſcular fibres alſo, by the help of which they are contracted to caſt out the ſperm, run through them; ſuch a contraction is common to all the other muſcular fibres, after they are drawn out of the body: I have ſeen even theſe veſicles, after being taken out of the body of the Bee, contract and wrinkle themſelves up by degrees. Here we ſhould well obſerve, that near the beginning of the root of the penis two remarkable nerves *n n* are inſerted in the ſpermatic veſſels, and which give many branches both to theſe veſſels and to the root of the penis, contributing to the motion and titillation of theſe parts. That part of the ſpinal marrow *m*, from which theſe nerves ariſe, is here delineated ſomewhat laterally. Near theſe nerves likewiſe, there appear two other little parts or ligaments *l l*, by the intervention of which the genital parts are tied or faſtened in their places in the abdomen, ſo that they cannot go out of their proper ſituation without force: this, however, I would not have underſtood of the root of the penis, and ſome other parts which are moveable, as ſhall be ſhewn hereafter.

Near the orifices of the ſeminal bladders and vaſa deferentia, when the latter are more contracted, the root of the penis ſhows itſelf, Tab. XXI. fig. I. *e e*; it is a conſiderable long and crooked tube; it becomes the more dilated and diſtended, the more it advances toward the outſide, until at length it expands itſelf into a globe of conſiderable thickneſs, and being then ſomewhat contracted again, it forms at laſt a more conſiderable oval tubercle or ſwelling. On the inſide in this dilatation of the root of the penis, there adheres a pelucid horny part, of a deep brown, but ſomewhat ruddy colour, and ſet with ſmall cavities *f*. This part appears to be divided in the middle, and in that place is ſeen the limpid and clear colour of the penis. In the anterior or fore ſide, but a little on one ſide of the part juſt now mentioned, may be obſerved two other horny, ſhorter, and ſmaller parts, which ſeemed to be joined together. The ſtructure of the root of the penis is nervous or cartilaginous, not yet hardened. Where this root is diſtended with ſperm, it is much whiter than where its ſubſtance is more plainly ſeen, being in ſuch parts limpid, and not ſo white, but rather reſembling glaſs. This is the caſe likewiſe in the ſeminal bladders; where theſe, not yet ſwollen with the ſeminal matter, preſent their proper ſubſtance to view.

Under the little part juſt now deſcribed, and ſomewhat on one ſide of it, appears the penis *g*, or the part that ſeems moſt analogous to a penis; of this I ſhall ſpeak more largely hereafter. On the other ſide is ſeen *h* that the genital veſſels, which appear to be diſtinguiſhed into five diviſions, and a little lower, and as it were on the other ſide, there is ſeen another ſimilar but undivided little part *i*, which when diſſected is found to be ſhaggy, unequal, and as it were briſtly. The former little part which is divided by five rings, appears alſo to be of the ſame ſtructure. Theſe three hinder little parts, as well as the ſubjacent and hollow appendages *k k*, appear wrinkled and contracted, like compreſſed, tender, and delicate membranes; the reaſon of which will be ſoon ſhewn. The ſeminal veſicles therefore, as has been obſerved, and the vaſa deferentia, as well in their beginning near the teſticles, as where they terminate after they have grown narrower, as alſo the root of the penis, every part of theſe is pellucid: wherefore, whenever they are diſcharged of ſeed, they appear like white glaſs, or like veal, or any other jelly: but when the ſperm is ſeparated in the veſicles or root of the penis, there is then a very fine appearance, as of glaſſy marble or agat, diſtinguiſhed or variegated with white ſpots. This is a ſhort deſcription of what belongs to the ſtructure of theſe parts: many things more may be obſerved, which I ſhall defer to another opportunity. If we conſider the uſe of theſe parts in coition, and the manner the ſperm is ſecreted, theſe are indeed ſo admirable that they almoſt ſurpaſs all that has been hitherto ſaid. For the little part which we have called the penis *g*, as alſo the other part with its five rings *h*, and the cloſed and pointed appendages *k k*, are all of them erected, and in the erection turn and invert themſelves in ſuch a manner, that their internal ſurface is turned perfectly out: this is done in the ſame manner as we take off our glove, or pull the ſkin off a Hare or other ſuch animal, by turning the inſide out. Hence I am in doubt whether this ſhould be called an erection, rather than an inverſion, produced by the heat of the parts; all theſe parts are at the ſame time alſo diſtended with air. Indeed I do not remember to have hitherto ſeen any thing in nature wherewith I can compare this action. I am ſenſible that Snails turn out their horns, and take them in nearly in the ſame manner; but the air contributes nothing to this, the whole action is evidently performed by the help of conſpicuous and elegantly conſtructed muſcles; but this does not happen in regard to the erection in the Bee. If many Bees are kept together in a box, it frequently happens that theſe parts are obſerved to turn themſelves out of their body in the manner juſt mentioned: and on this occaſion I have alſo found that the ſame thing may be effected by art; that is, by taking the body between the fingers, and then expreſſing or ſqueezing theſe parts out at the hinder part.

When the male is about to diſcharge the ſperm, or to erect or rather evolve the penis, then, that I may now ſpeak in general of the extuberance of the genitals, the cloſed and pointed appendages are turned out. This is performed in theſe as well as the reſt of the parts,

parts, by the air which is impelled inwards, for at that time they are all inflated with wind. The inverfion of thefe parts is performed in this manner; the extreme and hairy part, Tab. XXI. fig. III. *r*. of the pudendum is firft forced out by the Bee, and then the horny *q q* extremity of the fame pudendum is likewife advanced out from the laft rings of the body, and at the fame time the root of the penis *e e*, together with the faid horny part *f* contained in it, ftarts or is thrown forward, and the vafa deferentia *c c*, and feminal veficles *d d*, are likewife drawn fomewhat towards the fore parts. Afterwards the four diftinct little parts begin to fwell and throw themfelves out of the body; that is, the two pointed appendages *k k*, the pyramidal particles *i*, and the fine ringed little part *h*. Before thefe four parts are erected and thruft forth, one may fee in what manner they fwell forwards through four diftinct little cavities, fuch as are feen in the fingers of a glove, when you have juft begun to invert them. And further, one of the clofed appendages, as alfo, the little part with its fine rings are feen through the skin.

The appendages, as I have already obferved, are firft inverted, and their bafis is then turned out, Tab. XXI. fig. IV. *l l*, when we fee their clofed extremities ftill lying between them and not yet inverted. But the pyramidal little part alfo *i* is then unfolded more and more upwards, as well as the fine ringed little organ *h*; the horny part alfo fituated at the root of the penis *f* is then propelled or pufhed further forwards, and is fixed higher in the horny little part of the pudendum *q q*; but the hairy part of this is no way changed in its fituation.

Then the appendages being by degrees entirely inverted, appear diftended and fwollen, Tab. XXII. fig. I. *k k*, at which time the root of the penis *e*, together with its interior little horny part *f*, are moved yet farther outwards, and this begins to penetrate fomewhat deeper into the cavity *g g* of the horny or bony part of the pudendum: the pyramidal little part *i* alfo is now turned further out, and the little part with fine rings *h*, which is then partly inverted now appears to the eye: however, the fhaggy part *r* of the pudendum as yet fuffers no change.

But at this very time the pyramidal little part fig. II. *i* is at length all turned out and expanded, and the other little part likewife fhews itfelf: it has five divifions, and fhort briftly hairs; and it now appears very elegantly and beautifully bent *hh*. This makes the more agreeable fight, as thefe five divifions are of a bright red colour, but the reft of this little part is membranaceous and whitifh. The clofed appendages *k k* retain their figure, and only the horny little part fituated in the root of the penis, is by degrees more and more thruft out, and is further introduced into the horny part of the genitals. Hence it happens that the root of the penis *e* becomes ftraighter, whilft the fhaggy part *r* of the pudendum ftill remains as it was.

If one continues to prefs out thefe parts further, the skin being the pyramidal little part, and that which has five divifions, is by degrees widened and diftended; and hence it afterwards happens, that what is called the penis, fig. III. *g*, appears there in this manner; it turns itfelf entirely out, exhibiting a membranaceous ftructure, and beautiful corrugations in the head *t*. Then the pyramidal particle *i* likewife becomes entirely unfolded and expanded; and the horny little part *f* enclofed in the root of the penis, is entirely, with a great part of the root itfelf, preffed out of the body. This is forced through the middle of the horny, Tab. XXII. fig. III. *q q*, and hairy *r r* part of the genitals: hence the little part with fine rings is then likewife dilated and extended fo far, that on each fide it appears wholly reclined towards the hairy part *r r* of the pudendum. As thefe parts are pellucid, the horny little part *f* is feen through the skin of the penis, whilft in the mean time the little part with fine rings being plainly drawn down under it, refembles as it were an expanded membrane, and appears marked with fome lines or bright red grooves or furrows, between which are feen its five divifions. I do not think it neceffary to delineate all and each of thefe: but the clofed appendages *k k* are then, without any regard to thefe feveral changes, obferved to remain in their former figure and fituation.

Whilft thefe parts are in this ftate below the penis as it is called *g*, is feen a confiderable aperture *u*, which appears underneath and between the divifions of the horny little part fituated inwardly at the root of the penis; through this aperture, not only the faid little organ but a great part of the root of the penis may be forced, and thus will caufe the fperm to flow plentifully from thence. The before defcribed cavity of the genitals feems from hence, therefore, to be the true paffage *u* of the fperm, though for fome time I have attributed that office to what is called the penis *g t*; but I obferve that this as well as the other parts is clofed and has no orifice. Wherefore I cannot imagine what ufe this little part is of; as I do not yet conceive the purpofe of that other little part, which one may take for a penis. On the contrary, I think I very clearly fee that the internal horny particle *f* is made in order to dilate the root of the penis with its ftiffnefs, and to preferve it when opened, by which an eafy paffage is given to the femen through the latter. Indeed, in my opinion there was a neceffity for fuch a caution, on account of the great impetus wherewith thefe parts are forced out; for if that little part were not hard as horn, the faid paffage would be eafily fqueezed together, and confequently the ejection of the feed hindered. But whether thefe particles which are inflated with air, contribute to propel the reft of the parts out of the body, and whether

whether the cavity through which I ſuppoſe the ſperm paſſes, are natural or produced by the force wherewith I preſſed theſe parts out of the body, muſt be ſtill more accurately inveſtigated, for theſe are not ſufficiently clear to me.

It is now time to deſcribe the peculiar inverſion of theſe parts. The cloſed and pointed appendages, Tab. XXI. fig. I. *k k*, then begin firſt to emerge and to be inverted by degrees, fig. III. and IV. *k k*, until at length they are all entirely thrown out, Tab. XXII. fig. I. *kk*. At the ſame time the pyramidal particle prepares to iſſue, Tab. XXI. fig. III. and IV. *i*, and turning itſelf more and more about it, Tab. XXII. fig. I. becomes extuberant, until finally it is entirely extended, fig. II. *i*. Then the five ringed little part, Tab. XXI. fig. I. *h*, is obſerved, fig. III. and IV. *h*, to appear by little and little, and to invert itſelf, Tab. XXII. fig. I. *h*, until it is diſplayed a little more, and then it is entirely inverted, exhibiting to the eye a very beautiful ſight, fig. II. *h h*. In the laſt place, Tab. XXI. fig. I. *g*, the penis, as it is called, is by degrees propelled between the pyramidal part and that which has five diviſions, and is inflated with air, Tab. XXII. fig. III. *g*, *t*, and at the ſame time the quinquepartite little part is entirely dilated, and under what is called the penis, entirely towards the hairy part of the genitals *r r*. In the mean time whilſt theſe things are doing, the root of the penis *e* and its inward horny particle *f*, is by degrees moved forward and thruſt out of the body, ſo that the orifice out of which the ſperm is diſcharged *u* may be very diſtinctly ſeen.

As almoſt all theſe parts are thruſt out by force of the air, the reaſon is obvious why ſome of them, when not diſtended with air, appear wrinkled and contracted in the body, Tab. XXI. fig. I. *g h i k k*. It appears alſo for what reaſon I call this little part *g* the penis, and that is, becauſe it bears ſome reſemblance to a penis, Tab. XXII. fig. III. *g t*. Indeed, if it be perforated and erected by force of blood and ſperm, one may more properly take it for a penis than the fine ringed little part, which is likewiſe impervious. The poſterior part of this penis next to the body *u* is very beautiful, reſembling in brightneſs the foot of a cryſtal drinking glaſs with ſmall ribs, only that a little whiteneſs intermixed obſcures in ſome meaſure the brightneſs.

From the deſcription and figures of the genital organs thus exhibited, it is ſufficiently evident, that it is ſcarce poſſible that all, and indeed, hardly credible that any of theſe parts ſhould be admitted into the body of the female: wherefore, I firmly believe that the female Bee is impregnated only by the ſtrong effluvia of the male ſperm, after the Bee has diſcharged it: nor would I have this doctrine rejected by any perſon as abſurd though ſeemingly ſtrange. For firſt, though a penis or little part like it ſeems to be given to the male Bee, yet this is by no means ſufficient for impregnation; becauſe it is not only impervious, but by reaſon of its ſituation and figure, it cannot, I think, be admitted into the female's body. Nay, though the penis ſhould be admitted thither, yet it could not convey the ſperm into the uterus, the latter being diſcharged through a quite different paſſage. In Hornets there is a wonderful and diſtinctly viſible penis; on each ſide of it are ſeen two horny hooks like claws, by the help of which the male Hornet fixes himſelf to the extreme ring where the female's vulva is, and then advances its penis further into the uterus. In the Silkworms and in the horned Beetles the ſame may be ſeen ſtill plainer. I have found from experience that the male ſperm of Bees exhales a rank and ſtrong odour; ſo that if there be ſeven or eight males together encloſed in the little box, this is more ſtrongly infected with the effluvia of ſperm than any one could believe, who hath never ſmelled theſe ſeminal vapours. And though the parts alſo containing this ſperm have no aperture in the male, and the ſaid orifice was perhaps produced by me only, by the violent ſqueezing of the poſterior part of the body, yet it does not therefore ſeem leſs probable that the ſubtile particles of the ſperm may eaſily penetrate through the tender and inflated membranes of the genital organs, and by their effluvia only impregnate the female. Does not experience teach, that even the white as well as the yoke inſenſibly inſpire through the membranes and hard ſhell of the egg? Secondly, though the males were provided with a penis fit for real coition, yet they never have an opportunity of copulating with the female, ſince ſhe is always ſurrounded with great numbers of the working Bees, nor is ſhe ever any where left alone by them; ſo that one cannot by any means imagine that the working Bees grant the female a place and acceſs to exerciſe venery. But if any one objects, that the males probably engender with the female when they adhere about the cell, out of which the female iſſues; this cannot be allowed, ſince their genital organs are not obſerved to be conſtituted in ſuch a manner as to be accommodated to or for this buſineſs. However, if the aperture beforementioned, through which the ſperm flows, be naturally in the genital parts, I readily accede to the opinion of one of my friends, who thinks that the males when they penetrate through the noiſy ſwarm of the other Bees, rub a little of the ſperm upon the female's body, and thus impregnate her: but this opinion is deſtroyed if that orifice whence the ſemen iſſued is not natural. Upon the whole, it ſeems to me more probable, that the female is impregnated only by the ſtrong and very ſubtile effluvia of the male ſeed. For if only eight male Bees are able to emit a very ſtrong odour, what will four hundred of them together do in a hive? It is probable there is in general a greater number than this of males in one hive, which would not indeed be difficult to know, if one would count either the males themſelves, or the cells whence they are excluded. To which may be added, that other creatures impregnate their females only by contact, or by aſperſion or ſprinkling, as is plainly the caſe in Fiſh. In the fiſh kind we ſee plainly, that the eggs or ſpawn caſt by the female into the water, are only ſprinkled or daſhed with the melt or ſperm of the male, and are by this means fecundated. The ſame thing holds with reſpect to the Ephemerus, whoſe female flying in the air drops her eggs into the water, and the male then ſeeks after them, and ſprinkles and fertilizes them with his ſperm. As therefore the water ſerves Fiſhes as a medium, through which the impregnating virtue of the ſperm is communicated to the eggs, ſhall it be thought improbable, that the air is a medium of the ſame kind to the Bees, by means of which the ſubtile particles of the ſeed diſperſed through the hive, are transferred to impregnate the ovary of the female? Indeed the whole conſtitution of the genital organs of the male confirms this opinion. The ſame is likewiſe intimated by thoſe very ſtrong ſeminal vapours, which are perceived by the noſe, when even but a few males, at the time of ſwarming, lie encloſed for ſome hours in a box. To the reaſons hitherto advanced may be added, the golden or incomparable obſervations of Harvey, by which it is indeed evidently demonſtrated, that even in man and in brutes the ſperm never comes to the uterus, but that the more ſubtile and ſcarce perceptible particles of it change the whole body at the time of coition, and according to what I obſerved in the human ſpecies, impart or give a more perfect animation and motion to the eggs, while they are ſtill in the ovary. That the ſemen never comes into the uterus, appears moſt certain from the following experiment: let the penis of a Dog in the act of coition, be tied behind the knot which it then forms, and immediately cut off, and let the female be inſtantly opened, all the ſperm will be found ſticking in the vagina. In domeſtick fowls the Cock only emits his ſperm through two ſmall apertures, and rubs it to the vulva of the Hen; for he has no penis nor any remarkable production of the vaſa deferentia: in other inſtances theſe unite in one common channel, or, as in us, are produced out of the body by the help of the urethra: but in the mean time the ſubtile particles of this gallinaceous ſperm thus rubbed on the body penetrate through the membranes, nerves, veſſels, nay, through the whole body of the Hen, though they be intended to affect and impregnate only her ovary. In the ſame manner nearly the ſeeds committed to the earth, or being only on its ſurface, we ſee are affected by the earth's moiſture; ſo likewiſe a little barm, or yeaſt, ferments, moves and prepares the whole maſs. The little part which appears like a penis in the Bee, is wonderfully ſmall and delicate, and of a very beautiful ſtructure; and hence I preſerve it in my collection as a thing very worthy of contemplation. One doubt may be ſtill objected to the hypotheſis that I have advanced concerning the odiferous impregnation of the female Bee, and that is, that the female at the time of coition may thruſt the extremity of the vulva into the body of the male, as is evidently the caſe with ſome ſpecies of Flies. But I anſwer to this, that the extremity of the uterus in this female is not made in the ſame manner as it is in thoſe Flies: beſides that theſe arguments, by which I have before alledged that the male cannot eaſily approach the female, and that no coition can be performed amongſt the whole ſwarm of the buſy and noiſy Bees, ſtill remain unſolved. To which add, that it muſt be firſt very evidently proved, that the aperture obſerved by me about the horny little bone in the root of the penis, out of which I expreſſed the ſeed, is natural, and in its natural ſtate is emitted ſo far out of the body. Nay, and if all theſe ſuppoſitions were taken for granted, yet it would be hard to demonſtrate that this coition of the Bees is like that which obtains among thoſe Flies. The coition indeed of the Hornets, which is nearly related to the Bee kind, ſeems likewiſe to contradict this opinion. But, perhaps, ſome will rather maintain, that as ſoon as the female hath broken its cell, the male immediately creeps into it, and begins to copulate with her while yet in the cell. And among many other reaſons this may be alledged as one, why the cells of the females are much larger than thoſe of the other Bees. But all theſe matters are merely conjectural, and they are not only contrary to the ſtructure of the genital organs, but they ought not, nor can ever be admitted as certain, only ſo far as they are eſtabliſhed by trial; nor can I think it is impoſſible to know by experiments how this female is impregnated. However, my opinion is, that this impregnation happens by means of the effluvia only; it remaining thus far ſufficiently ratified and confirmed. The female, therefore, at the time of ſwarming, becomes fecundated by only the ſeminal effluvia of the males, which diffuſes itſelf in the hive; and hence the tripple ſeed in the ovary of the female acquires its fertility; that is, ſome thouſands of the eggs, out of which the working Bees are produced, then ſome few eggs out of which the females are excluded, and ſome hundreds which produce males. But the two latter ſpecies of Bees are not generated in the hive until the year following, unleſs when the hive is to ſwarm again the ſame year; for then the males iſſuing from thence perform that buſineſs again for the ſubſequent year.

If the reader views the admirable ſtructure of theſe genital organs, and the exquiſite art conſpicuous therein, according to their worth and dignity, he will indeed ſee that God, even in thoſe minute inſects, and their parts, has concealed from the incurious eye, ſtupendous miracles; nor is it difficult to diſcover and illuſtrate theſe things, provided one ſeduloully applies to their inveſtigation. Conſider, therefore, what a progreſs acute and ſagacious geniuſes may make

make in these inquiries, if they will industriously search into them. What I have hitherto described and exhibited, are indeed but light shadows of the things themselves: it would be easy for ingenious persons to discover and lay open all these things thoroughly and more perfectly, to the glory of the great God *. As to myself, I do most willingly confess that my capacity is so slender, that I am able to behold the works of God only at a distance. Nay, the more frequently I view them, the more I am convinced of my ignorance, and I know my own weakness and misery.

To make what has been hitherto described the more intelligible, I shall add the figure of the genital parts of the great water Beetle, in which the testicles are very remarkable for their structure.

Tab. XXII. fig. v. *a*, the penis itself, which is situated in the midst between the prominences of the horny part, and is inflated and erected in coition by the help of the blood.

b b, The horny part of the penis, in the middle of which it is placed, and is strengthened thereby.

c c, The root of the penis formed in the same manner as in the Bee.

d, The testicle of one side, as it appears at first sight, when disengaged from its pulmonary tubes.

e e, The testicle freed of its pulmonary tubes, so that its internal structure, which is tubular, or consists of small and round filaments, may be seen.

f f, The vasa deferentia, whereof one extremity, as in man and brutes, issues out of the testicles, or rather is joined to the tubulated filaments thereof.

g g, The vasa deferentia dilated, or that part of them where they secrete a certain seminal matter, as well in man as in the Bee.

h h h h h h, The seminal vesicles with their curled extremities: these appear in that part not unlike the seminal vesicles in man.

i i, Vessels closed at their ends, which open about the root of the penis, and probably perform the office of prostrata in man.

Finally, to conclude this history of the anatomy of Bees, I shall subjoin a description of the spinal marrow, and shall delineate it, and explain the figures. All other things which may be further said of these insects, such as the description of the bony or horny parts of the Bees, I shall pass over at present in silence; for as the Bees have now employed me continually for some months, dissecting in the day time, and writing at night, I am the more inclined to put an end to the present treatise, though I clearly see that some parts of this insect may be still much more accurately investigated. However, I should scarce believe that I have committed any considerable errors; therefore I confidently submit to the censure of those who have candour, and shall never refuse to learn better things.

The spinal marrow of the male Bee, Tab. XXII. fig. VI. *a*, knotted in its beginning, or that part of the brain which in the description of the eye dissected before, I have said was joined to or continuous with the brain, the cortical substance and transverse fibres. This part, which gives origin to the nerves of the eye, is very easily separated from the parts just now recited, if it be in the least handled. I have not yet examined how the eyes are constituted in other insects, and in the Silkworm, with respect to the brain or spinal marrow; I have delineated only their nerves as they appear in the Worm or Caterpillar, as may be seen in the figure which I have before inserted in the history of the Rhinoceros Beetle; where is likewise seen very distinctly, the nervus recurrens, or recurrent nerve, which I have here afterwards observed in the Bee.

b b, 1, 2, 3, &c. Shew the seven subsequent little knots of the spinal marrow, into which the marrow, when it passes through the breast and abdomen, is dilated. These same letters likewise shew the origination of the nerves from those parts.

c c c c, Are some nerves which do not arise from the marrow where it is dilated, but from the division of the two larger nerves which constitute the marrow.

d d d, &c. Are those places where the marrow is divided or opens. This is never seen in man, nor in larger animals.

e, The part of the marrow situated in the head, and that in the neck. The part in the neck lies enclosed in a small horny part.

f, The part of the marrow which is placed in the thorax, and there principally provides for the muscular fibres that move the legs, wings, &c.

g, The part of the marrow enclosed in that narrow horny little part, by which the body is joined to the breast.

h, The part of the marrow situated in the abdomen, which gives nerves not only to the viscera, but to the muscles of the rings, and to the sting.

i i, Two remarkable nerves distributed over the jaws, and other parts. They are the same that I have before exhibited in the figure of the eye.

k k, Two nerves reaching to the proboscis or trunk, serving probably for the taste.

l l, Two other nerves which are conveyed into the muscles of the trunk. I could not yet investigate the olfactory and auditory nerves in this creature.

m m, Two nerves transmitted out of the beginning of the marrow towards the eyes, as I think. This, however, I cannot assert for certain, as I do not love to deceive either myself or others, for it is a difficult thing to see this matter

* This author died before the invention of glass hives. These have been carried to such perfection since, that we can see the whole course of operations of the Bees carried on in it. It is thus we have discovered their true oeconomy.

matter diſtinctly, becauſe the upper parts of the brain are here united to the marrow.

n n, Two nerves ſent off from the thorax to the upper muſcles of the body, and together with the marrow encloſed in that narrow filament which connects the thorax with the body.

o o, Two ſtrong nerves, which are for the moſt part inſerted in the root of the penis, and other organs of generation, as has been ſhewn in the figure of thoſe parts.

Fig. VII. *p p*, &c. Part of the marrow repreſented ſomewhat magnified.

q q, &c. The external medullary ſubſtance, reſembling a divided nerve.

r, Another portion of marrow, put between its proper medullary ſubſtance; by the acceſſion or addition of which the marrow is dilated into a little knot. This is by no means ſo white as the medullary ſubſtance itſelf, but ſomewhat gray, and approaching to fleſh colour; therefore perhaps the marrow is by the intervention of ſuch a different ſubſtance dilated and made more firm, in order to ſtrengthen it for omitting its nerves. This may be likewiſe ſeen fig. VI. under the letters *c c*, where even the medullary ſubſtance itſelf becomes thicker: probably this dilatation ſerves alſo for another purpoſe; for that dilating matter ſeems to me to be of the ſame nature with the ſubſtance of the brain in this inſect, and agrees with the cortical ſubſtance, and the tranſverſe fibres. I ſhould in this place add a delineation of the pulmonary tubes, whereof theſe nerves have a conſiderable number, but that I am certain as adequate an idea may be had by the deſcription of them. That ſubſtance which is lodged between the medullary matter, hath been before me ſhewn by the juſtly celebrated Malpighius, in his excellent treatiſe on the Silkworm, and he has alſo delineated the pulmonary tubes there. I had reſolved to ſtop in this place, but upon reconſidering my obſervations, I found ſomething in them belonging to the hiſtory of the Bees, which I ſhall firſt explain. I ſhall in the firſt place give a brief hiſtory of the inſect called the Bee-hive Wolf, or Lupus Alvearius: this is an inſect, which, when it comes into the hives of Bees, ought to be conſidered as their deſtructive plague, becauſe it conſumes and eats all their wax. This creature, properly enough called Lupus or Wolf by the Bee-keepers, is a Vermicle like, as to form, to a ſmall Caterpillar. Tab. XXVI. fig. II. *a*, the body, computing the laſt annular inciſion of the tail, is divided into fourteen rings; on each ſide of the body are nine points of reſpiration; the firſt and laſt of theſe, which indeed I think are peculiar to the inſect, are as large again as thoſe that are placed between them. The pulmonary tubes are white, and appear diſtinctly through the body. The body itſelf is nearly ſmooth, being ſet only with a few ſcattered, thin, and oblong hairs. When this creature contracts itſelf, ſeveral regular whitiſh folds or wrinkles are produced in its ſkin. In the head are to be obſerved, the eyes, the teeth, one lip, ſome articulated briſtly hairs, and a papilla or nipple that ſerves for ſpinning. The whole Worm is fleſh coloured, except when the colour is ſomewhat changed by the contents of the inteſtines ſeen through the ſkin. It moves itſelf in the ſame manner as the reſt of the Caterpillar kind, and runs backwards and forwards with equal celerity: for this uſe it has ſixteen feet, that is, ſix fore feet, eight middle, and two hind feet. The fore feet are furniſhed with ſharp claws, and the middle and hinder feet ſhew a conſiderable number of ſmaller nails in the extreme circumference of their ſoles. This Caterpillar is produced from a ſmall kind of an oblong egg, which is laid in the combs by a grayiſh Butterfly *b* of the Moth kind. It is a very deſtructive Caterpillar that proceeds from this egg *a*, for it not only corrodes or gnaws the combs, becauſe it feeds on wax, which I think it has in common with the Worms of the Humble Bee; but wherever it paſſes, it likewiſe gnaws round holes through theſe waxen cells: by this means one Worm ſometimes breaks open and deſtroys fifty or ſixty ſuch cells. We muſt particularly obſerve, that this Worm, wherever it penetrates, always fabricates or forms an hollow and tubulated web *c c*, in which, as in a rabbit burrow, it can very ſwiftly paſs from one part to another, and very ſpeedily run back again. If you attempt to catch this Worm at that time, you will ſee it by the help of the claws, wherewith its hinder feet are armed, very firmly fix itſelf. Unleſs this creature be ſoon expelled, or be killed in the beginning by the Bees themſelves, and carried out of the hive, it fills the whole comb with ſuch webs, and turns itſelf in them every way into various bendings and windings: ſo that the Bees are not only perplexed and diſturbed in their work, for they frequently intangle themſelves by the claws and hairs of their legs in thoſe webs, and the whole hive is deſtroyed. That I might be able to inveſtigate more accurately the true nature of theſe little creatures, I have ſometimes given them food for a time. When I have for that purpoſe expoſed a comb of wax in a drawer of my cabinet to the open air in my chamber, the whole comb has been in a very ſhort time eaten up by numbers of ſuch Worms. But I always firſt obſerved many of their Butterflies fluttering about my chamber. Nay, I ſaw ſome of theſe Worms ſo famiſhed, that they devoured the ſoft part of the bodies of ſome dead Bees, which had ſtill ſtuck in the comb; nay, did not leave even their wings. They made very wonderful burrows, Tab. XXVI. fig. II. *c c*, through the comb. Beſides this particular Caterpillar, there is another ſmaller, that likewiſe iſſues *d* from a little ſpecies of Butterflies, and does great miſchief to the combs corroding and eating away the wax. This Caterpillar is not only deſtructive to the wax, but to the Bees themſelves, for it buries and kills many of them; but this happens only by chance. I ſaw one of theſe little

Worms,

Worms, whilſt it was ſmall and was breaking the cells, in which the Nymphs of the Bees lie, and eating the wax there, cover the Nymphs alſo with its excrements, inſomuch that they could be ſcarce known. To this may be added, that the Worm itſelf, when, in order to get food, it creeps every where round about the Nymphs, compreſſes and deſtroys them : this miſchief is occaſioned chiefly by one that is more grown, the body of which demands ſomewhat more ſpace. I have learned theſe matters much againſt my inclination, and have been full of indignation againſt the Worm, when with its excrement it defiled and killed ſome Nymphs, which I had deſigned to obſerve in their changes.

As this Worm uſes wax for its food, its excrements are nearly of the ſame nature ; if they be received upon a thin plate of glaſs, and put over a burning coal, they melt at firſt like wax, but afterwards they harden, and like the burnt Bee-bread, become friable between the fingers. Theſe excrements are of a black colour, and of an hexagonal figure, and when chewed they exhibit a ſweetneſs and tenacity like wax: a tincture may be extracted from them by ſpirit of wine, ſuch as hath heen uſed to be prepared out of the excrements of ſome other animals, and then applied to medicinal uſes. Nor would it indeed be difficult to gather together a great quantity of theſe excrements; provided their uſe was known. After this Worm hath eaten ſufficiently it forms, Tab. XXVI. fig. II. *e*, to itſelf a new oval white web, and encloſes itſelf therein, ſometimes covering the circumference with its excrements. Sometimes each of theſe Worms weaves ſingly, and ſometimes forty or fifty of them perform this work together : in ſome time afterwards they are changed into Chryſallides or Aureliæ *f*; ſo that we ſee they belong to the ſecond method of the third order of natural transformations or accretions in the parts. Finally, theſe Worms having acquired the figure of Chryſallides, caſt their laſt skin in their webs, and at length creeping out of them appear winged animals *d b*, and aſſume the perfect form of their parent Butterflies. Theſe frequently pitch about the doors or other openings of hives, and as it were ſollicit admiſſion, but they are very aſſiduouſly kept out by the Bees: they are indeed formidable enemies to the Bee, though theſe and all other ſpecies of Moths, are very weak creatures, which may with the fingers be eaſily reduced to duſt. The Bees, however, do theſe Butterflies no miſchief, unleſs when they by their irregular flying, which is common to almoſt all Butterflies, ſtrike the Bees with their wings, or when they too obſtinately attempt to creep into the hive. The ſmaller ſpecies of theſe Moths is of a grayiſh colour, and has four ſomewhat glittering wings, ſix legs, and two long and ſharp-pointed antennæ or horns placed juſt over the eyes. The other ſpecies which is larger is of a more dusky colour, and has wings ſomewhat ſpotted, in the middle of which, or in that part where they reſt upon the body, are ſeen on each ſide three ſmall eminences, compoſed of feathered little ſcales, formed in the ſame manner with all the reſt of the Butterfly ſcales; for they are not real feathers which produce theſe wonderful and very beautiful colours of the wings of thoſe creatures, but rather ſcaly little parts ſupported by little ſtalks. Aldrovandus hath delineated this ſpecies of Butterflies, and he gives it the name of the hive Moth.

One may ask naturally why the Bees ſuffer theſe Worms, which deſtroy and conſume their workmanſhip ſo terribly, to live in their hives? and this ſeems the more ſtrange, becauſe the Bees kill their own males about the end of auguſt, break their wings with their teeth, and carry them out of the hive, nor do they leave them, till they are perfectly dead. Nay, they do not admit other Bees, nor ſuffer Hornets to enter their hives. The ſolution of this queſtion is eaſy and obvious, for the principal reaſon conſiſts in this, that the female is then either barren, or does not lay eggs enough, and conſequently does not multiply the number of the Bees as ſhe ought to do, or is perhaps mutilated, maimed, without wings, or weakened by ſome other means. When theſe things happen, as the working Bees have no Worms to feed, or whoſe cells they ſhould build, or even when the hive is too large, on account of the ſmaller number of the Bees that inhabit it, than is requiſite to contain them and their iſſue; on any of theſe accounts the progeny of the Bees occupies the upper part of the hive, and the working Bees, throwing off all care of preſerving their cleanlineſs and neatneſs, lead a careleſs, idle, and irregular life, and gather but little honey; nay, if the males be in the hive, when in this condition, they by no means kill them, for they have nothing to mind or take care of but feeding themſelves, and they throw off all affection for the preſervation of their progeny, and have too much time to fly about and provide for themſelves; therefore, having no occupation, they live very diſorderly, and will leave their males alive till the winter is far advanced *. In this caſe they let the moths enter unoppoſed; they will likewiſe ſometimes creep underneath into the hive, that they may lay their eggs in the wax. This happens chiefly when the Bee keepers neglect to ſtop up on every ſide the lower verge of the hive, though the Bees themſelves ſometimes take care of this

* Among the moral virtues attributed to Bees, none is more celebrated than that of their burying, as it is called, their dead. Thoſe who firſt eſtabliſhed this opinion, ſaw Bees carrying others which were dead to a diſtance from the hive, but Reaumur has explained this, and robbed the creatures of the glory they had retained for their ſuppoſed charity through centuries. It appears from the moſt ſtrict examination, that this is done in care for themſelves, not in regard to the dead. They often murder thoſe they thus carry out, and when the ſtores are likely to fail, they will kill even the Worms and Nymphs, and throw them out of the hive. They carry them to a diſtance, becauſe they hate a ſtench.

matter. When therefore the Bee-keepers fee a hive fallen into this misfortune, which they may eafily perceive, or indeed prevent, provided they now and then turn up and thoroughly examine the hive, it is their bufinefs inftantly to cure it. The Wolf Caterpillar is to be expelled from the hive, by cutting and breaking open the unfinifhed wax; and if the female be fick fhe muft be killed and the Bees put into another hive. If in this other hive there be too fmall a number of Bees, two or three hives muft be put together, the Bees affociated, and to avoid new confufion one of the females muft be likewife killed: the working Bees muft be compelled by fome of thefe means to mind their duty; and this may be very eafily done, fince they follow nature as their guide, and need no other mafter. Befides this Caterpillar produced from the Moth kinds, there are other creatures that are enemies to the Bees, whereof Virgil in Georg. IV. fays,

For lurking Lizards often lodge, by ftealth,
Within the fuburbs, and purloin their wealth,
And Lizards fhunning light, a dark retreat,
Have found in combs, and undermin'd the feat:
Or lazy Drones, without their fhare of pain,
In winter quarters free, devour the grain;
Or Wafps infeft the camp with loud alarms,
And mix in battle with unequal arms:
Or fecret Moths are there in filence fed,
Or Spiders in the vaults their fnary webs have fpread.

Dryden's Virgil.

It is a common opinion that the Bees in rough and boifterous weather, and particularly in a violent ftorm, carry a ftone in their legs, in order to preferve themfelves by its weight againft the power of the wind. Hence Virgil in Georg. IV.

Nor dare they ftay,
When rain is promifed, or a ftormy day:
But near the city walls their watering take,
Nor forage far, but fhort excurfons make.
And as when empty barks on billows float,
With fandy ballaft failors trim the boat;
So Bees bear gravel ftones, whofe poifing weight
Steers through the whiftling winds their fteady flight.

Dryden's Virgil.

But this, as Clutius juftly obferves, has not been hitherto remarked by any Bee-keeper, nor indeed have I myfelf ever feen it. Yet I fhould think that there may be fome truth in this matter, and probably a certain obfervation, which I fhall prefently mention, has given rife to the ftory. There is a fpecies of wild Bees not unlike the fmalleft kind of the Humble Bee, which, as they are accuftomed to build their nefts near ftone walls, and conftruct their habitations of pieces of ftone and clay, fometimes carry fuch large ftones, that it is fcarce credible by what means fo tender infects can fuftain fo great a load, and that even flying, whilft they are obliged to fupport alfo their own body. Their neft by this means is often fo heavy as to weigh one or two pounds; though only ten or twelve young Bees are brought up in it. This I have obferved in the year 1666, at the country houfe of Mr. Thevenot, fituated in the village of Iffy, not far from Paris, near the bottoms of fome windows, in the prefence of Dr. Steno. In this neft I at that time found a red Worm, with fix legs, Tab. XXVI. fig. III. *a*, which was changed into a Nymph *b*. But this Nymph after in the fpace of a whole year did not change into a Bee, but into a very beautiful Beetle *c*; nor could I in the mean time obferve that this Worm, in all this time, took any confiderable food, unlefs perhaps the ftony and clayey particle of this neft ferved it for food. See further the explanation of the figure. Befides, I likewife found there a fingular kind of Wafp, and in fome oblong hollowed tubes, I alfo found the membranous webs of Bees already broke open and deferted. From all thefe appearances it is therefore evident that 'tis poffible Bees may be fometimes feen to carry little ftones, but thefe were not common Bees, nor have I hitherto found that any perfon has obferved this practice in them. The nefts juft mentioned were likewife known to the learned Aldrovandus, but thofe he faw were made as it were of clay only, as may be feen in his remains or chronicles, where he rudely delineates the Worm of the little Bee, together with the neft, and relates that Ariftotle alfo, in Hift. Anim. Cap. 24. makes mention of this fpecies of Bees; but as Ariftotle in writing his hiftory did not apply himfelf to anatomy, he could therefore fcarce advance any thing certain; and hence it has arifen that his account is very confufed, for he undoubtedly compiled it from the relations of others, and this often leads into the greateft errors. Indeed, nobody can accurately underftand thefe my obfervations, unlefs he hath borrowed light from the experiments themfelves *.

As Bees frequent only herbs, plants, trees, and flowers, carefully avoiding fuch things as are ever fo little ftinking or foul, and therefore are never feen to light, much lefs make any ftay upon the dead carcaffes of animals; the account given of Sampfon in the book of Judges chap. xiv. is a paradox with fome, whilft others look upon it as altogether incredible. Sampfon, according to that hiftory, having killed a young Lion, found in fome days after a fwarm of

* In fwarming, one Bee with its fore legs lays hold of the hinder legs of the Bee next above it, and fometimes they ufe only one leg for this purpofe, laying hold only of one of the hinder legs of the Bee next above. In this manner they hang from the bough, or whatever other fubftance the firft has fixed upon; and this firft fupports the weight of all the reft. The whole clufter, though fingly they are light, is of confiderable weight, and by this we may form fome idea of theftrength of this infect.

Bees, and a quantity of honey in the Lion's carcafs *. However ftrange this event may appear, even to the ingenious and fagacious obferver of Bees, I can difcover nothing like a paradox in the relation. The context clearly proves that the thing happened in the midft of fummer, at which feafon the carcafs of any animal that had perifhed by a violent or natural death, would in a fhort fpace of time be fo entirely cleared of its flefh, as to form no more than a skeleton. In this the Bees might find a commodious habitation. Is it not a common thing to meet on the roads with the ribs and other bones of dead animals, fo thoroughly ftripped of the flefh, and at the fame time covered with part of the skin fo dried, and in a manner tanned, by the weather, that infects may find under it fufficient fhelter and convenient lodging? No doubt: the text runs as follows: After fome days Sampfon found a fwarm of Bees in the Lion's carcafs. We muft, indeed, underftand by thefe words, that the interval between his killing the Lion and finding the honey in its carcafe was not very long; nor is there any occafion for underftanding them otherwife, fince at the time that Bees fwarm, there are many infects, efpecially the Worms from which the common Flies fpring, which, from their ravenoufnefs and great numbers, may devour, in a few hours as I may fay, the carcaffes of dead animals to the very bones. There are many fpecies of Flies that will fmell a carcafs at a great diftance, and immediately depofit their eggs on it, as a proper place for their little Worms when hatched, as they very foon are, to find a food fuited to their nature. It is almoft incredible how faft thefe Worms will grow, and how fuddenly they will eat up all the flefh of a carcafs. I have experienced this by hanging a dead Duck to the branch of an apple-tree, at the feafon when Bees fwarm: in three days after the Worms have fuddenly broke from their eggs, the Duck's flefh and entrails have been entirely confumed, nothing remaining but the bones and a few tendons, fo that with very little pains it might have been formed into a perfect fkeleton. We fee in this inftance how greedily thefe Worms devour, and how faft they grow, immediately upon leaving their eggs. The fame obfervation alfo has been before made by that curious naturalift, the illuftrious Redi, in his experiments concerning the generation of infects. His words are thefe: "What was moft "furprifing, the Worms were fo much grown "by the next day, that they each weighed "about feven grains; whereas before twenty "or thirty of them did not exceed one grain. "The other Worms that ftill continued to "come from the eggs began, as I may fay, in "the twinkling of an eye, to devour what "flefh remained on the Fifhes, foon leaving "the bones quite bare like fo many fkeletons, "that would not have fhamed the hands of the "beft anatomift in Europe." I remember that as I was once travelling on a very hot fummer's day through the province of Utrecht, in my way to Culemburgh, in order to make fome obfervations on the Ephemerus, I took notice of a dead Horfe that lay by the fide of the road, and was fo full of Worms, that no part of its flefh could be any longer diftinguifhed; nor was the number of thefe infects more furprifing, than the waving motion they produced in the remains of the flefh, bowels, and other parts of the carcafs, which by that means appeared in a manner ftill poffeffed of life and motion. A great number of the Worms, unable to find room and nourifhment in it, were then crawling on the road, where the heat and duft foon ftifled them. Another time I had an opportunity of obferving to what a degree of perfection thefe are poffeffed of the fenfe of fmelling; for having put fome little Worms hatched from the eggs of Bees into a box, in order to trace and examine, if poffible, their change into Bees, a few of them died; they were no fooner dead, than, the box not being well fhut, fome little Flies took notice of their carcaffes as a proper nidi for food and fhelter to receive their eggs. Accordingly I had Worms produced in them in a very fhort time, which at length changed to that fpecies, which I call the fourth order of natural mutations, and in a few days after perfectly refembled in fize, ftructure, and form, the Flies from whofe eggs they were originally produced. Things of this kind occur moft frequently in very hot fummers; for then both the Flies and their Worms are multiplied in a furprifing manner. When the bones of animals have been once cleared from their flefh in the manner already mentioned, it is no difficult matter to conceive how they may in a little time be fo wafhed by rain, as fcarce to be diftinguifhable from the pureft ivory.

As then it plainly appears by the hiftory of Sampfon, that his adventure of the Lion happened about the time when Bees fwarm, make their combs, and fill them with honey, we muft of courfe fuppofe it was during the great heats of fummer, when Flies lay their eggs; fo that the offspring of thefe eggs might, in all probability, have devoured the flefh and entrails of the Lion, within the time requifite to folve all the difficulty that can be ftarted upon this occafion; befides, alternate rains, funfhine, and dew, may be eafily fuppofed capable not only of bleaching, as already faid, but of purifying alfo, and freeing from all manner of ftench, or difagreeable fmell, the bones that remained, fo as upon the whole to make the carcafs, or rather the

* The conftruction of the cells of the Willow Bee is very extraordinary, nor are thefe found in combs: they are frequent in our fen countries. I have feen thoufands of them in Lincolnfhire; the Worms make themfelves cafes of the leaves, and bury themfelves in the rotten part of the wood. The Worm of the working or hive Bee is a very weak creature, but thefe are vigorous and active: they wrap feveral entire leaves round their bodies, and faften up the ends of this hollow cylinder with pieces of other leaves gnawed off for that purpofe, and ftuck together with a kind of wax, made principally from the buttons of water flowers. Thus they lie covered and buried till their change. This fhews nature ufes various methods.

the skeleton of the dead Lion, a proper place of reception for thofe little cleanly animals. We are not to imagine with the generality of mankind, that Bees at the time of their fwarming fend out before them as it were fome of their nobles or courtires, to prepare lodgings fort he reft of the company; by no means: the whole clufter feizes the firft opportunity of fixing themfelves, be it houfe or tree, or the corner of a wall, no matter whether high or low; and if they do not find their fituation agreeable, or if no body comes with a hive to receive them, they foon fly off again, and fo ramble about from place to place, till they find of themfelves, or till fome one offers them, a convenient habitation. And thus it is probable that Sampfon's Bees had acted, till they at laft fettled in the Lion's carcafe, where they built their combs and depofited their honey: God himfelf, who governs all things, and from whom this work, or, as the holy writings exprefs it, Sampfon's conduct proceeded, directing the motions of thefe little infects, fo as to afford a fubject for a riddle, and confequently a juft excufe for delivering his people. I had once an opportunity of obferving how irregular Bees will fwarm, in a houfe belonging to Mr. John Oort, now magiftrate at Nieuwenrode, that had greatly fuffered by fire. I found the fwarm in one of the remaining walls, where they had made both wax and honey; but their choice of this place was highly imprudent, for the hole by which they were to go in and out of their habitation was fo large, that they could not by any means keep off the winter's cold, and their number alfo fo fmall, that they had not provided food enough to fubfift them at home on the fevere days when they could not go abroad. Sometimes I have feen fwarms of Bees hanging to the topmoft branches of the loftieft trees, and at other times, content with fo humble a fituation, that the clufter their fwarm formed in a manner touched the earth.

It is probable that the not rightly underftanding Sampfon's adventure of the Lion, gave rife to the popular opinion of Bees fpringing from dead Lions, Oxen and Horfes; and this opinion may have been confiderably ftrengthened, and indeed in a manner confirmed, by the great number of Worms that are often found during the fummer months in the carcaffes of fuch animals, efpecially as thefe Worms fomewhat refemble thofe produced from the eggs of Bees. However ridiculous this opinion muft appear, many great men have not been afhamed to adopt and defend it. The induftrious Goedaert has ventured to afcribe the origin of Bees to certain dunghill Worms, and the learned de Mei joins with him in this opinion; though neither of them had any obfervation to ground their belief upon, but that of the external refemblance between the Bee and a certain kind of Fly produced from thofe Worms. The miftake of fuch authors fhould teach us to ufe great caution in our determinations concerning things which we have not thoroughly examined, or at leaft to defcribe them with all the circumftances obfervable in them. Therefore, although this opinion of Bees iffuing from the carcaffes of fome other animals by the power of putrefaction, or by a tranfpofition of parts, be altogether abfurd, it has had notwithftanding many followers, who muft have in a manner fhut their eyes in order to embrace it. But whoever will attentively confider how many requifites there are for the due hatching of the Bee's egg, and for that infect's fubfiftance in the Worm ftate, as has been particularly explained in the preceding pages; whoever, I fay, confiders all this with the attention it deferves, cannot be at a lofs for a clue to deliver himfelf out of that labyrinth of idle fancies, and unfupported fables, which, entangled with one another like a gordian knot, have even to this day obfcured the beautiful fimplicity of this part of natural hiftory. Nor need we complain that by overturning this fyftem, we lofe examples by which many moral precepts may be enforced; there will remain a fufficient number of folid obfervations to anfwer the fame purpofe. Thus mutual love, friendly cohabitation, and uninterrupted courfe of good offices, obfervable amongft Bees, who behave in all this as if they were actuated by chriftian principles, and lived in a real communication of all good things, with their induftry, by which their happinefs is conftantly encreafed, are powerful motives to engage us in the fame practices. It is this love, this communion and diligence, that governs, fupports, gives motion and life to their little republicks; and if we contemplate the inftitutions of the primitive chriftians, we fhall find they lived in the fame manner.

It is a difficult matter to determine any thing in regard to the period of life which nature has alotted thefe infects *; at leaft I muft own that I have not as yet been happy enough to hit upon any fatisfactory experiments on this head. Some perfons who have made Bees their ftudy, affirm as a certainty that working Bees live but one year, and I am not averfe to their opinion, though I do not think they have as yet any fure obfervations to ground it upon. On collecting all the Bees that die in a hive in one year, we find their number equal to that of the furviving. In autumn and winter, when the Bees neither fly abroad, nor carry their dead out of the

* The Bee, which is fo able to defend itfelf in the perfect ftate, is, while in the condition of the Worm and Nymph, liable to deftruction by that moft contemptible creature the Mite. Millions of thefe get into the hive, whofe paffage would be defperately defended againft larger affailants; and they make their way into the cells and devour them. This was firft obferved of a kind of Bee that breeds in rotton willows, and the account is given at large in the Philofophical Tranfactions. It has fince been difcovered in the common kind; and the mifchief has been often done where it was not fufpected how.

hive,

hive, an idea may beſt be formed of the degree of mortality that prevails amongſt them: at thoſe times their dead carcaſſes are found at the bottom of the hive by handfuls together. Now, if by adding to thoſe that die in this manner, all ſuch as fly off and never return, or that periſh in the fields in cold and rainy weather, or are devoured by Swallows and Dragon-Flies, daſhed by the wind againſt the leaves and branches of trees, or entangled in the webs of Spiders, we may eaſily gueſs that a far greater number of them periſh within the year, than thoſe which are to be found alive in the hive. We likewiſe obſerve in the autumnal ſeaſon, that the wings of Bees are often mangled, broken and wounded, and they appear ſo alſo in the beginning of the ſpring; whereas at the time when they ſwarm, their wings are ſound, entire, and in good order: all this makes it more probable, that Bees live but one winter, or from one ſeaſon of ſwarming to another. They may ſometimes, however, be obſerved to continue in the ſame hive for years together, provided part of the wax is now and then taken away; but this happens in the ſame manner that in great and populous towns the number of inhabitants is kept up by thoſe who come by degrees into the world, and inſenſibly ſucceed ſuch as ſickneſs, accidents, or old age, carry off. Beſides, the working Bees which have outlived the ſwarming ſeaſon and the winter, have performed the task aſſigned them by nature, namely, that of keeping each other warm in the cold weather, and nurſing the riſing generation: which neceſſary tasks being done, it it found that all other inſects hitherto obſerved, and ſome a little ſooner, and others a little later, periſh. Thoſe for example which immediately ſhed all their ſperm, diſappear before the reſt; as is plain in the Ephemerus, whoſe eggs are arrived at their full perfection from the very birth of the parent, and ſo provided for by nature, as to render the parent's care of them altogether needleſs, whereas other inſects muſt live longer, either becauſe the maturation of their eggs requires ſome time, or becauſe their eggs require a ſlow hatching. This is the caſe with the female of the Bees, and ſome other inſects; hence we may very probably conclude, that the female of the Bees lives longer than the working kinds, as it is impoſſible that ſhe ſhould lay all her eggs at one time. However, it is not yet ſo certain as we might wiſh how long ſhe lives. I believe it might be eaſily known by following the advice of Clutius, and contriving to make her ſo that ſhe could be readily diſtinguiſhed; and the beſt way to do this, would be, I imagine, to make a very little puncture in her wings, or elſe to cut off ſome inconſiderable portion of them with a pair of ſciſſors, or otherwiſe to ſtain the edges of them with ſome oil colour. Thus we might ſoon learn in a certain manner, what ſpace of life nature has aſſigned to this little creature. I am of opinion that ſhe either dies, or grows barren at the age of two years. But it is by no means ſo eaſy to try this or any other experiment I can think of, upon other Bees, on account of their numbers, and our not knowing the exact time of their birth. The working Bees come into the world at almoſt every ſeaſon of the year; and although the young Bees appear in greater numbers at the ſwarming ſeaſon than at any other, yet they are hatched ſome earlier than others by one, two, three or four months; for ſome of them do not creep out of their eggs, till a long time after the ſwarming time; and this I have likewiſe found to be the caſe with the males. Add to this, that the female is very aſſiduouſly employed in laying her eggs ſo early as the month of March, which makes it neceſſary that ſome of them ſhould be hatched ſooner than others; and conſequently this renders any judgment we ſhould form of the length of their lives altogether uncertain; for how is it poſſible, where there are ſuch numbers, to diſtinguiſh between the old and the young? Certainly no one can do this: nor is there any poſſibility of alledging any thing certain concerning the natural extent of life allowed the male Bees, though I believe it ſcarce exceeds ſix or eight weeks: but I cannot affirm that I am ſupported in this opinion by any ſufficient experiments; and I fancy that if any can be made to aſcertain it, they will coſt a great deal of time and trouble. Some perſons have aſſured me that they have ſeen male Bees alive in winter, when the female Bee had not been ſo fruitful as ſhe generally is. Be this as it will, I can only ſay, that all theſe things deſerve to be more attentively examined; for as the male Bees every ſeaſon ſuffer a violent death, nothing as yet can be determined concerning the natural extent of their lives. In the mean time, as I have, ſaid I am not againſt the opinion of thoſe who ſuppoſe it but ſix or eight weeks. There are ſome obſervations which induce me to think it is thus, beſides thoſe general laws of nature, by which theſe little animals are doomed to die, as ſoon as they have executed the commiſſion given them by her of propagating their ſpecies; for this buſineſs being over, the male Bees become altogether uſeleſs. This is plain in the Ephemerus, and likewiſe in the Silkworm Butterfly, which generally dies the third day after laying its eggs, unleſs the ſeaſon happens to be cool, for then theſe inſects will live longer. I believe this is owing to a plain cauſe, that the vital juices of thoſe little animals who eat nothing during their appearance in this form, do not exhale ſo readily in cool as in hot weather, and conſequently the means of life longer remain.

I have made a collection of about three thouſand inſects, ſuch as Butterflies, common Flies, Beetles, Locuſts, Caterpillars, Worms, Chryſallides, water inſects, and others; amongſt which I muſt not forget to mention, ſix kinds of wild Bees *: the firſt of them is that which builds its neſt with ſmall ſtones, grains of ſand, and clay; and in this reſpect ſo much reſembles the Humble Bees, that we may indeed reckon it of their number. There is another ſpecies, Tab. XXVI. fig. IV. of a ſingular ſtructure: its head and thorax differ ſcarce at all from thoſe of working Bees; but its belly is altogether different, for this part is thick ſet with hairs of a yellowiſh red, ſo as to look as if it was ſprinkled with ſome liquor of that colour; its laſt ring is armed with three ſharp prickles, and there are two more points of the ſame kind on the ſecond of the rings forming the belly. Its legs are covered with yellowiſh hairs, but that which grows under the horns, on the fore part of the head, and between the diviſions of the breaſt and belly, is almoſt white; as to the length and bulk of the body, it nearly agrees with the female of the working Bees, except that it is ſomewhat ſhorter. The third ſpecies, fig. V. is of a thicker and more compact body, and in ſize and ſtature nearly reſembles the male of the working Bees, but it has ſhorter wings; its head and eyes are formed in the ſame manner with thoſe of the working Bee; but under each antenna there is a yellow ſpot, which may ſerve as a mark to diſtinguiſh this ſpecies; beſides, the upper part of its trunk is coloured. The breaſt and head are covered with gray hairs, and the extreme joints with pretty long hairs of the ſame hue, but ſomewhat darker. The fourth ſpecies, fig. VI. is remarkable chiefly becauſe its antennæ or horns are three times thicker and four times longer than thoſe of the working Bees. Its trunk alſo exceeds that of the working Bee in length and thickneſs. Moreover, all its back, or the upper part of the thorax, and ſome parts of the belly, are adorned with bright red hairs inclining to yellow. This circumſtance, with the extraordinary ſize of the horns, is the beſt diſtinguiſhing mark of this ſpecies. It is alſo one third larger than the working Bee. The fifth ſpecies, fig. VII. is on the other hand ſomewhat leſs, and differs in its colour, and the hairs growing on its limbs, from all other Bees. The hairs of its breaſt and legs are of a deep gold colour, and the two upper joints of its hinder legs, which are likewiſe the largeſt, are quite covered with hairs of the ſame kind and colour, but much longer; whereas there is no hairs at all on the lower joints. The extreme borders of the rings that conſtitute the belly are alſo adorned with the ſame kind of hairs, only that they are of a fleſh colour, and much ſhorter. The ſixth ſpecies, Tab. XXV. fig. X. is ſomewhat leſs than the working Bee; the hairs of its head and breaſt are of a more duſky colour than thoſe of the Bees before deſcribed. On the other hand, its belly conſiſts of blackiſh rings of a ſubſtance between bone and horn, and ſtreaked on each ſide with little lines at ſome diſtance from each other. The coverings of the legs, which are of the ſame ſubſtance with the rings of the belly, are yellow, and the legs themſelves are thicker than thoſe of working Bees or Waſps, which makes me imagine that this little creature is provided by nature with no ſmall degree of ſtrength. All theſe ſix ſpecies of inſects agree with the three other kinds mentioned before, in this, that they have all ſix legs, four wings, and two antennæ or horns, and are divided into the head, thorax, and body. There appear alſo in ſome of the ſpecies three ſmall and ſeparate eyes, beſides the two great ones. The ſix laſt ſpecies are very ſeldom found in ſwarms together; they generally ramble alone and by themſelves, which makes it probable that they do not dwell together like working Bees. They are ſeldom found in the fields, but often in flower gardens, where the flowers ſupply them with honey. As to their gathering of wax, ſome appear quite unfit for that taſk, on account of the great quantity of hairs that grow on their legs.

I preſerve alſo two kinds of Hornets, of different ſizes, which I therefore diſtinguiſh by the names of the greater and leſſer Hornet. They are eight times as large as the working Bee, and reſemble it much leſs than they do the Waſp. They have four wings, fig. IX. *a a*; the outer pair are fixed to the ſhoulder-blades, of three times a greater extent than the inner ones. They have alſo ſix legs joined to the fore part of the breaſt, and the extreme joints are armed with two ſharp claws *b b*. The head *c* is ſomewhat oblong, eſpecially when the teeth or jaws lie cloſe together. The eyes are formed like a creſcent, and above in the interval between them there are three ſeparate ſmall eyes, under which there are two horns. The Hornets have likewiſe two very ſtrong teeth or jaws, divided into a great many very ſmall ones, and between the two principal teeth they carry a very ſhort trunk. The body is joined to the breaſt, which is pretty broad, by means of a very ſlender thread as it were, and conſiſts of ſix pretty ſtout rings of a ſubſtance between bone and horn. Theſe are yellow at the edges, but red on the upper part, and equally marked with dark brown furrows, from which on each ſide run eight ſpots formed as it were by the ſprinkling of a brown liquid, but on the ſecond and third ring, reckoning from the head, there appears a ninth ſpot, ſo as to form ſomething like a

* Beſides the addition careleſs authors have made to the Bee kind, by ranking two winged Flies among the number, we have eleven diſtinct ſpecies in England. Mr. Ray, who was indefatigable in theſe reſearches, counts nine; and ſince this two others have been found. They are very ſmall, one is black entirely, the other black and red on the body: they make regular combs, and are found principally in the weſt of England. They build in cracks of rocks, in walls, or in very dry banks of earth.

triangle. The head, breaſt, and legs, are almoſt of the ſame colour, and they are covered with very delicate hairs. The ſting is produced from the opening of the lower ring, Tab. XXVI. fig. IX. *d.*

Of the Waſp kind I preſerve nine different kinds, amongſt them is that which I found in the neſt I have already mentioned, as made by the Bees that uſe little ſtones for that purpoſe. The greateſt difference that occurs between the various kinds of Waſps, conſiſts chiefly in ſize and colour, though in one or two kinds there is beſides a great diſagreement in their ſtructure. But I ſhall not dwell long upon theſe particulars. The larger kind of Waſp is above three times as big as the working Bee, and has like them and Hornets, ſix legs, a proboſcis, two eyes, two horns, and four wings. The body of Waſps, as well as Hornets, converges to a point, and is ſhaped in the ſame manner with that of the particular Bee which vulgarly goes by the name of the king Bee. The rings of the body are variegated with blackiſh ſpots, and circular furrows upon a yellow ground. This general deſcription will, I hope, be ſufficient to ſhew what kind of an inſect the Waſp is. That repreſented in fig. VIII. is ſomewhat leſs than the largeſt ſpecies of all. Under it is to be ſeen another of a very ſingular ſtructure, fig. XI. *

I have beſides theſe eight kinds of Humble Bees or Bombylii, which differ from each other in ſize and colour. One kind has its body exceeding black, and is furniſhed with moſt beautiful wings of a colour between azure and purple. The largeſt kind is ſeven times as big as the largeſt working Bee; and this has a pretty long trunk. Its legs notwithſtanding are ſmall in proportion to its ſize. The head is ſomewhat oblong: the eyes are formed like a creſcent, and the horns lie directly between them. The breaſt is very broad, and it is covered thick with rough hairs; from the bottom of it ſpring ſix hairy legs, which if compared with the body, are very ſhort, and from the upper part of it riſe four wings; the inner pair very ſmall. The belly is very broad and hairy, and ſomewhat pointed on the lower part. The hairs that grow thus on the belly, are placed principally near the rings of it, and they are of a great variety of colours, as white, yellow, red, black, and others in ſome kinds; whereas in other ſpecies they are only of two. The Humble Bee, or Bombylius, of which I here give a drawing, Tab. XXVI. fig. XII. is of a middle ſize.

Of the Pſeudoſphecæ Ichneumon, or baſtard Waſps, I have by me twenty-five kinds. Theſe differ from each other in ſize, colour, and ſtructure. I refer them to the Waſps merely on account of the external reſemblance which ſome of them have to real Waſps, from which, however, in generation and diſpoſition they widely differ: moſt of theſe proceed from a Chryſalis, after having lived ſome time in the form of a Worm. Theſe alterations are performed in a very ſurpriſing manner; and as that from a Nymph to a Waſp takes up three or four weeks, the ſeveral gradations of it in point of colour, growth, and expanſion of members may be very accurately traced. Some of theſe baſtard Waſps which I preſerve in my collection, prey upon Flies; others upon Spiders, whoſe legs they break to pieces and then devour them. There is likewiſe amongſt them the Fly called Uniſata, or one briſtled, having one hair at its tail, and that which is diſtinguiſhed by the name of Tripilis or three-haired, fig. XIII. for theſe Flies are all baſtard Waſps: I cannot now treat particularly of them, as it would require a large volume. For the ſame reaſon I omit ſpeaking in this place of the diſpoſition, nature, method of propagation, and ſtructure of Hornets, Humble Bees, or Bombylii, and of the true Waſps; nor do I chooſe to ſay any thing of the inſects called Veſpatæ or ſhort Waſps, their building, houſes, and other remarkable particulars, of which I have ſome ſpecimens. I am poſſeſſed of a moſt curious Hornet's neſt, fig. XIV. and XV. as likewiſe of the male and female Hornet, the Worm from which they originally proceed, the web in which this Worm is encloſed, the exuviæ it caſts off on becoming a Nymph, and all the excrements it voids, together with the internal coat of the ſtomach and inteſtines. I can likewiſe ſhew the Nymphs of Hornets at various periods of their changes, and the rudiments of thoſe new colours which they by ſlow degrees attain. As to the internal parts of Hornets, I have the membranaceous net-work of a ſtomach of one, ſome pulmonary tubes, one of the ſilk or ſpinning bags, and a ſpinal marrow.

In my collection alſo are various kinds of Flies ſo like Bees, that ſome authors have called them by that name. Such is Goedaert and J. de May's Bee, which has only two wings. This is a ſufficient mark to diſtinguiſh theſe inſects from each other, though there are ſome Flies that have two pair of wings. Such is one in my muſeum, which is very beautiful, furniſhed with tufted antennæ, and in other reſpects like a Bee, only that it is a great deal larger. What is moſt ſingular in this Fly, is its proceeding originally from a water inſect. But as I have already ſaid an

* Some of the Bees breeds with us in the free air, not in a hive or comb. The young are bred up in the caſes of the lilac or other leaves; and there is ſomething very extraordinary in the manner of their hatching. The cells ſeem to cloſe up the paſſage of one another, and it would be thought the young creature in the hindermoſt muſt eat all the reſt to pieces to get out, for they are built in ſucceſſion after it: but though the whole caſe of cells be the work of many days, the young all hatch together; the eggs laid lateſt having obtained a forwardneſs in the body of the female, which make them diſcloſe their young as ſoon as the firſt.

entire

entire volume would be requiſite to deſcribe all theſe particulars; for which reaſon I ſhall here make an end of this treatiſe upon Bees. Certainly the nature, diſpoſition, and ſtructure of theſe inſects are ſo ſurpriſing, that they without ceaſing loudly proclaim God's goodneſs, wiſdom, power, and majeſty; and indeed all other animals, according to their ſeveral ranks, do him honour in the ſame manner, and conſtitute in the air, the water, and upon the earth, ſo many inſtruments and voices to publiſh his praiſes. I will join the univerſal choir, and ſay with the four and twenty elders in the Apocalypſe, "Thou art worthy, O "Lord, to receive glory, and honour, and "power; for thou haſt created all things, and "for thy pleaſure they are and were created." I ſhall conclude this long eſſay upon Bees with the words of the royal Pſalmiſt.

"Praiſe him all ye angels of his; praiſe "him all his hoſt." Pſal. cxlviii.

Some peculiar obſervations relating to the hiſtory of Bees.

A deſcription of a hive opened the tenth of March, with an account of the number of cells it contained.

ON the tenth of March laſt I opened a hive *, in which a young ſwarm of Bees had been ſettled during the month of June, the preceding year, but they all died in the intervening February for want of honey. I examined the cells built from the month of June till the winter ſeaſon, that is in the ſpace of about four months, and counting them one by one, I found them to amount to 22,574; and the whole of this prodigious number was only of that kind of cells, in which the working Bees are hatched and nurſed, or the honey and Bee-bread is ſtored up. Thoſe in which Bees had been already hatched, amounted to 7814; for it was very eaſy to diſtinguiſh them certainly from the others, by means of the ſkins and webs found in them, ſuch things being always left behind by Bees that have been hatched. All the other cells were formed for keeping honey, and the other cells are made to anſwer the ſame purpoſe, as ſoon as the young Bees contained in them have acquired wings to fly abroad.

It appeared likewiſe that all theſe cells were contained in nine combs, as they are generally termed, or nine portions of the whole wooden ſtructure, and theſe portions were large, oblong; of different forms, ſome diverging equally, others running out into two, three, or four angles. This variety in the figures of the combs is owing to ſome of them being built alone by themſelves, and others cloſe to each other; or to the neceſſity the Bees were under of keeping clear of the ſticks placed acroſs the hive to ſupport the wax, for this occaſions them to make their combs ſometimes of a triangular, and ſometimes of other forms. Nor can we perceive, that in this buſineſs the Bees obſerve any certain rule or order, ſince the figure of the cells themſelves does not ſuffer by this liberty they give themſelves.

Many of the little cells in which the honey was ſtored up, were twice as long as thoſe intended for neſts and nurſeries, and were alſo irregularly built, crooked, and full of angles. Even the ſides of the hexagonal cells did not every where exactly correſpond with one another, but here and there might be ſeen a gap large enough to contain a pin's head, a thing never to be met with in a truly regular comb.

All the half combs of cells on one ſide of the perpendicular foundation, which runs through the middle of them, and againſt which the cells are horizontally placed, were built full one half as long again as thoſe on the other ſide. There appeared here alſo many other irregularities, not to be ſeen in the cells that had ſerved the purpoſe of hatching, ſuch of them at leaſt as had been quite finiſhed.

From this prodigious number of cells, built between June and September, or October, we may entertain ſome idea of the great number of thoſe that the Bees conſtruct from the month of March to the June or July of the following year. I believe they may amount to 50,000, as this is the time for ſupplying with cells the male, female, and working Bees: but as yet I have not counted them.

A perſon fond of Bees, and whoſe account I could credit, once told me that he had a hive placed upon the bare ground, and exceedingly well ſtocked with Bees, inſomuch that to make room for their combs, they had hollowed out the earth under their hive, extended their conſtructions very deep into this hollow, and thereby encreaſed their numbers to a prodigious degree. But this is oftener practiſed by Waſps and Hornets, as theſe inſects naturally make their neſts under ground.

* The danger of being ſtung by Bees may be in a great meaſure prevented by a quiet and compoſed deportment; and even when they have given the wound, the ſame ſedateneſs is the beſt conduct. A thouſand Bees will fly and buz about a perſon without hurting him, if he ſtand perfectly ſtill, and let them alone: but if he ſtrike at them, probably he will be ſtung. If this happens, he ſhould ſuffer the Bee to reſt upon his fleſh in quiet: if it be let alone it will draw out the ſting, and the conſequences will be leſs troubleſome; but if diſturbed, the ſting is left in, and the wound is much the worſe.

A hive opened the 14th of June, the number of Bees and Nymphs found in it, with a particular deſcription of many other ſingularities not as yet known.

IN the beginning of June I bought a hive of Bees, it produced a ſwarm the 14th of the ſame month. I received the young Bees in another hive, and put this hive in water the day following, with all its new inhabitants. By this means I found the ſwarm conſiſted of one female, four males, and 2433 working Bees, who had not made any wax ſince they ſwarmed.

The 16th of the ſame month, I likewiſe drowned in the ſame manner the Bees that remained in the original hive, from which otherwiſe a ſecond, and even a third, ſwarm might have been expected. In this hive I found one female, 693 males, and 8494 working Bees. While I was employed in counting them, I let the water run off from the hive, that I might afterwards ſatisfy my curioſity in aſcertaining the number of their cells, but I found the amount ſo great, eſpecially that of the cells belonging to the working Bees, that I thought proper to deſiſt, for fear of loſing the opportunity of making ſome other obſervations, that I imagined better deſerved my attention.

I therefore reckoned with great care and exactneſs the little dwellings of the female Bees, and found nineteen of them as yet building, but ſome a little more forward than others. There were beſides fifteen more, in ſhape reſembling a pear, and quite finiſhed, which were all cloſed up with wax, and curiouſly diſpoſed on the edges of the combs. Some of them ſtood by themſelves, others lay cloſe to each other, three, four, or five together. Others again were built quite cloſe to the cells of the male Bees; ſome were ſituated obliquely; others horizontally, ſo as to reſemble a beer glaſs lying on its ſide; and, in the ſame manner, all the cells of both males and working Bees. Some on the other hand were built in an inverſe poſition, with their openings looking downwards, as the cells of Hornets are generally found. Finally, I diſcovered the cell of a female eat through on the fore part, being that out of which the young queen Bee had eſcaped that led the ſwarm of the 14th of June.

In nine of the cells belonging to the females, which I found cloſed up as juſt now mentioned, there were as many female Bees arrived at their full ſize, and furniſhed with wings ready expanded; and ſome of them were ſtill alive. Some of theſe females were quite gray, and others of a ſomewhat darker colour, according to the time that had elapſed ſince they had changed their ſkins, and that which they were ſtill to continue within the cell. Not one of them had as yet attempted to open itſelf a paſſage to fly abroad.

In the other five of the covered and cloſed up cells belonging to the females, I found as many Nymphs of females. One of theſe five cells contained a Nymph, which already begun to grow gray on the back, and was upon the point of throwing off its old skin; but in the other four Nymphs there was no appearance of this colour, they being as it were ſtill in their infancy, and for the moſt part reſembling in whiteneſs the curds of milk. The eyes alone had by degrees acquired a watry purpliſh colour, and the ſame might be obſerved of the three diſtinct ſmaller eyes, which are more conſpicuouſly perceivable in the inſect, while it remains in this ſtate, than afterwards when grown to its full perfection.

Under the belly and tail of theſe Nymphs, I found the exuviæ and air tubes that had dropped from them, on their exchanging the form of Worms for that of Nymphs. I could alſo perceive the remains of their food, which on pouring water upon it looked like ſoft ſtarch, or gum tragacanth, beginning to ſwell; it was of the colour of pure amber, and of a ſomewhat ſubacid flavour.

In the upper part, under the wax with which theſe fourteen cells were cloſed up, I could diſcern the web which the Nymphs ſpread in that part, while they continue in the form of Worms. The upper web was very ſtrong, and made of diſtinct threads, but in the lower part of the cell it looked like a membrane; for at the time theſe Worms labour to ſhut up their cells with ſuch webs, they are obliged to move their bodies in every direction, and thereby rub their food, and perhaps too their excrements alſo againſt their work, ſo as to fill the intervals between the threads that compoſe it with a kind of glue, and thereby reduce its ſurface to an evenneſs like that of a natural membrane.

I opened beſides all the cloſed up and covered cells of the males; many of theſe cells were ſituated near thoſe belonging to the working Bees, and contained in a ſingle comb, hanging at the bottom of the hive. The reſt of the male's cells were built in the midſt of thoſe of the working Bees, with common party walls or partitions. Of theſe cloſed up cells belonging to the males, I reckoned in all 858. In 234 of them I found as many Worms, which had not as yet changed to Nymphs, but ſome of them were nearer that period than others. In 146 cells there was the ſame number of milk-white Nymphs, which had but juſt thrown off their ſkins. In 44 more cells the eyes of the Nymphs were juſt beginning to acquire a watery and light purpliſh colour. In 414 other cells I found as many Nymphs, whoſe eyes were of a deep purple. And laſtly, in the 20 remaining cells there were Nymphs juſt upon the point of ſhedding their skins, and appearing in the form of male Bees: the gray and hairy members of the young males appeared plainly in theſe, through the tranſparent membrane which ſtill encloſed them.

After this I reckoned all the other male cells, and found them to amount to 1508, of which 720 were entirely empty, the male Bees sometime before hatched and bred up in theſe, having taken their flight; 268 more were not as yet perfected, nor had been uſed for hatching; 520 of the ſame cells, in which alſo no Worms had been yet hatched, were full of the pureſt virgin honey. I counted beſides all theſe 1701 empty oblong cells, which, though conſiderably bigger than the male cells, were not unlike them: neither had any hatching been performed in theſe, their form not being regular enough for that operation; therefore they could only ſerve to lay up honey. This circumſtance likewiſe makes me imagine that theſe oblong cells are not to be looked upon as male cells, but to be reckoned amongſt the ſtore houſes which the Bees build for their winter proviſions; for we find they make cells of the ſame oblong form, but like the cells of the working Bees, to anſwer that purpoſe.

The number of cloſed up cells belonging to the working Bees amounted to 6468, and in all of theſe I found Nymphs under the ſame variety of circumſtances with thoſe which I had found in the male cells. It is therefore needleſs to waſte words in explaining their different appearances, nor had I leiſure to count the numbers at every period of growth and ſtep towards their perfection: beſides ſome of theſe Nymphs began to have a very diſagreeable ſmell.

I reckoned alſo 210 cells full of Bees-bread, which was alſo heaped up here and there in the combs of the working Bees, in particular cells diſpoſed between thoſe which had Nymphs in them, or which were full of honey, but none of theſe bread-cells were cloſed up.

As to the remaining cells, thoſe newly built, as well as the empty ones, in which Bees had been hatched, and thoſe conſtructed the year before as ſtore-houſes for honey, or nurſeries, I had not time to count their prodigious numbers. Neither did I count the cloſed cells, which were diſpoſed in the upper part of the hive, and were now ready to burſt with honey. But my curioſity led me to weigh the honey itſelf, and I found it amounted to ſeven pounds.

In all this hive I did not meet with a ſingle egg, nor with any Worms, but ſuch as were full grown; ſo that by this time the working Bees muſt have got over the heavieſt part of their yearly labour, for there was no longer any neceſſity for building cells, or nurſing of young Bees, nothing more remained but the agreeable task of gathering honey for the ſupport of themſelves, and of the males and females, and making preparation for the ſecond, third, and fourth ſwarm, which I could eaſily ſee were to be produced from the different ſtages in which the Nymphs of the the future queens appeared, and from the different periods at which it was of conſequence neceſſary theſe ſhould make their appearance abroad. This induces me to believe, that the old females continue, even during the intervals of ſwarming, their labours for the propagation of the ſpecies, as I have already obſerved in deſcribing the hive opened on the 22d of Auguſt.

Many of the working Bees belonging to this original hive were ſtill of a grayiſh colour, which is a certain proof that they have not been long out of their cells. Nor did I obſerve one amongſt them that had loſt its wings; whereas ſuch crippled Bees are frequently ſeen in ſpring or autumn. This circumſtance makes it probable, that moſt of the laſt year's male Bees had been taken off by a violent or natural death, and ſucceeded by a new generation. Nor need this opinion appear improbable to any, for if on the 14th of June I could count 6468 Nymphs in one hive, and 2433 Bees in one ſwarm, we may eaſily gueſs what a prodigious number of Bees muſt be produced in the interval of time between March and June, and that between June and September; no doubt a multitude ſufficient to ſupply a hive with a number of new inhabitants, three times greater than that of thoſe which had poſſeſſed it the preceding year, or ſummer months, ſuppoſing them all to have unfortunately periſhed: the queen alone ſurvives a longer time, though I can ſcarce believe her life is of above two or three years.

As by what I have here obſerved, it plainly appears, that fifteen young female Bees had been produced in one hive, and in the ſpace of time required for one ſwarming; and as experience informs us that Bees ſeldom ſwarm in this country above three or four times, and that after the laſt ſwarm they kill their queens, which are then no longer of any uſe, we may conclude that at this time the old and impotent queen undergoes this fate, and is ſucceeded by a young one, better able to propagate the ſpecies. This opinion indeed ſtands in need of more experiments to confirm it, and ſuch experiments may be eaſily made by any one who is willing to ſacrifice a few hives to his curioſity.

It is ſurpriſing how tenacious of life Bees are; after the hive and all its inhabitants had, in conſequence of my orders, been kept under water for a conſiderable time, and I had begun to count them, as if they were pefectly ſuffocated, they began by degrees to recover life, as it were, and fly about the hive, ſo that I found myſelf under the neceſſity of cauſing them to be again put under water, and though I had reaſon to think none of them could outlive this ſecond ſubmerſion, yet there appeared many after it with ſigns of life, and ſome of them recovered themſelves ſo well as to live after this three days and two nights without eating.

That I may now exhibit at one view every thing, that I obſerved in the original hive, and in the ſwarm produced by it, and that the ſum of both Bees and Nymphs added together may be more diſtinctly known, I ſhall ſubjoin the following account:

One

One full grown queen in the ſwarm,	1
One full grown queen in the original hive,	1
Full grown queens in the cloſed up cells,	9
Full grown working Bees in the ſwarm,	2433
Full grown working Bees in the original hive,	8494
Full grown males in the ſwarm,	4
Full grown males in the original hive,	693
Nymphs of queens,	5
Nymphs and Worms of working Bees,	6468
Nymphs and Worms of males,	858

Theſe numbers added together make 18966 for the total number of all theſe little animals contained in a ſingle hive before it ſwarmed; at which time 2438 of them iſſued forth in ſearch of a new habitation.

The number of cells, the old and new built ones, thoſe which were ſhut up and contained Nymphs; the empty cells, and thoſe of working Bees full of honey *, or Bee's bread, all excepted, was as follows:

Cells of queens begun or finiſhed	34
Cells of males ſhut up, empty, and thoſe which, after the Bees had left them, were filled with honey,	2366
In all	2400

Do not all theſe particulars diſplay in a ſurpriſing manner the inſtinct, diligence, and dexterity, which it has pleaſed the all-powerful Creator to beſtow on theſe little inſects?

An account of ſeveral wonderful particularities diſcovered on opening a hive, that had a few days before received a young ſwarm.

HAPPENING to be in the country on the 25th of July, I obſerved a great ſwarm of Bees, which, on its hanging to an Elm, I ordered to be received into a hive; but in a little time they all left this new habitation, and fled back to the elm, where they hung entangled by each others legs. The female Bee had not dropt into the hive with the others: I was therefore obliged to have recourſe to another ſhaking; when having brought the female into the hive, all the reſt ſoon followed.

On the 26th of July the weather was tolerably good, with a bright ſunſhine; the 27th cloudy; the 28th and 29th rainy: on the 30th on examining the hive, I found at the bottom of it upon the ground where it ſtood, a piece of a honey-comb, which had fallen thither, either becauſe it had not been ſtrongly enough faſtened to the top of the hive, or becauſe too many Bees had lighted upon it at one time. This piece of a comb contained 418 cells of for the working Bees, ſome were building, and others were finiſhed, and there were alſo ten eggs ſticking to the wax by one of their ends. All the forenoon of the 31ſt it was rainy and about midday very cloudy and windy, with ſome rain. In the evening I ordered the hive to be taken into my chamber, in order to examine what the Bees had done in the ſpace of theſe ſix days.

But as I was afraid of being ſtung in this enterprize, I reſolved to have all the Bees killed before I went to handle or inſpect them, for this reaſon I fumigated them with a bundle of lighted matches rolled up in linen rags, to ſuch a thickneſs, that it would juſt fit in the upper opening of the hive. All my endeavours to kill theſe Bees this way were however to no purpoſe; for after plying them with this fume, from eight o' clock to eleven, lighting the matches from time to time, as they went out, the Bees continued alive; but they ſeemed grievouſly complaining of, and reſenting the injury offered them, with the moſt horrid noiſe and loudeſt buzzings.

The next morning all was quiet again, ſo I removed the hive, at the bottom of which I found ſome hundreds of Bees lying dead upon the ground; but the greateſt part of them were ſtill alive, and ſome of them were beginning to fly away. I therefore reſolved to fumigate the hive a ſecond time, and I gave its inhabitants liberty to eſcape while it was doing. For fear of being ſtung on this occaſion, I took a half pint bottle, and having rolled ſome ſoft paper about the neck of it, thruſt it into the opening of the hive, taking care afterwards to ſtop all gaps between the door or opening of the hive, and the neck of the bottle with more paper of the ſame kind. As ſoon as the ſulphurecus vapour began to fill the hive, the Bees in the greateſt hurry and confuſion and with the moſt dreadful buzzing, ruſhed to the number of 1898 in a manner all at once into the bottle, which I then removed to ſubſtitute another in its place; and by repeating the operation in this manner, I at laſt ſo thoroughly accompliſhed my purpoſe, that not the leaſt noiſe could be heard in the hive.

Having then turned the hive upſide down, I found the queen lying dead, in appearance, upon the ground, and ſome of the others which had fallen upon the ground, killed downright and wet all over; whilſt ſome other Bees that had remained in the upper part of the hive, were quite dry, and when put into the bottles flew about as briſkly as if they had not received the leaſt harm.

I next poured ſome water upon the priſoners I had in the bottle; by this means they were all drowned in a very ſhort time. I then made my examination, and found the ſwarm con-

* Maroldi, by the moſt careful examination, and on the reſult of the ſtricteſt calculation, has proved that the pyramidal figure of the bottom of the cell in a honey-comb is determinately and exactly that, in which the ſubſtance of the cell takes up the leaſt room, and the ſpace contains the greateſt viſible quantity of honey.

ſiſted

fifted of 5669 Bees, and was therefore a very good one, according to the judgment I had formed of it on its firft appearance. Neverthelefs, as the feafon was very far advanced, and the fpot the Bees lighted upon very ill furnifhed with materials for making honey, I thought it worth while to facrifice them to the curiofity I had of knowing what work fuch a number could perform in fo fhort a time, and withal in fo unfavourable weather.

Among this great multitude, there was but one female Bee. The greateft number of them were working Bees, which are neither males nor females; and there were befides thefe and the female Bee already mentioned, only 33 male Bees, prepofteroufly called by the vulgar hatching Bees; for the young Bees are hatched by the mere heat of the fummer, and that which is caufed by the perpetual hurry and motion of the old Bees flying about, or working in the hive. It is very remarkable that the bottle into which the firft 1898 Bees driven out of the hive had been received, was thoroughly heated by the perpetual motion of thefe imprifoned creatures, and the warm vapours which exhaled from their bodies.

The number of waxen cells begun and finifhed, including thofe of the comb I had found on the ground on my firft examining the hive, amounted to 3392: they were all of the fame fize and form, and were intended only for nefts to hatch the working Bees. In 236 of the cells fome honey had been ftored up, but it had been afterwards made ufe of, as very little could be then gathered abroad. It was no difficult matter to diftinguifh the cells thus made ufe of from the others, for they had received a yellow tincture from the honey depofited in them; whereas thofe which had not as yet been employed this way were of a fhining white.

There were alfo 62 of thefe cells, in which the Bees had already begun to lay up their ordinary food or bread called erithace. This fubftance was of a changeable colour, between a yellow and a purplifh red; but perhaps this tinge might be owing to the fumigation: the whitenefs of the unemployed wax was in fome parts alfo impaired by the fame means; coloured and covered befides with black fpots.

In 35 cells I found as many eggs fixed in them at one end, fo that including the eggs found in the comb, which had fallen to the ground as already mentioned, there were 45 eggs in all. There were befides in 150 of the cells fo many new hatched Worms, but thefe lay almoft infenfible and motionlefs. They were of different fizes, the largeft of them being very like that reprefented under the letter *c*, fig. XIII. Tab. XXIII. All thefe Worms were furrounded with that kind of food, which the moft expert obfervers of Bees think is honey thrown up by the old ones, out of their ftomachs. This kind of honey is white, like a folution of gum tragacanth, or ftarch diffolved in water, and is almoft infipid: it fhews nothing remarkable on being viewed with the microfcope. In the Worms themfelves I could perceive pulmonary tubes of a filver whitenefs running moft beautifully on each fide through their little tranfparent bodies.

I examined attentively the wax cemented by way of foundation to the top of the hive, but I could find no difference between that and the other wax of which the cells confift. They appear both to have the fame nature and properties. I could not, however, but admire this ftrong union or faftening; this fubftance being juft fpread upon the hive like a cruft, and confequently faftened to it by a very fmall portion of its furface; whereas the reft of the wax hung perpendicularly from this foundation, without any lateral or other fupport whatfoever, as if a wooden bowl were fixed to a plain ceiling by a fmall part of its circumference.

This hive contained the rudiments of a great many more fuch combs of wax, of an oval form, and full of cells on each fide: the empty fpaces left between the combs, for the Bees to pafs and repafs, did not exceed half an inch in breadth, fo that it is plain the comb I found open upon the ground, and in which I reckoned 418 cells, had been torn from its foundation by its own weight, and that of the Bees walking upon it. Hence it appears, with what good reafon thofe who keep Bees, place fticks crofsways in their hives, that the combs may have the more fupport; and accordingly we obferve that in thefe hives, the Bees themfelves on each fide fufpend their combs to thefe fticks.

Confidering the great multitude of Bees employed in building the waxen cells, which I have been juft examining, there is no great reafon to be furprifed at their having done fo much work that way, though the time they had to do it in was fo fhort; and the weather fo unfavourable. But it is really aftonifhing to think how a fingle female could lay fo many eggs in the fame fmall interval, and withal depofit every egg in a feparate cell, and there firmly faften it. We muft alfo allow fome time for laying the perpendicular foundations. It is, moreover, very furprifing how thefe eggs fhould fo fpeedily turn to Worms, and how thofe Worms fhould grow fo very fuddenly to their ftate of change. But I muft now conclude, and I fhall do it with the following account of what the hive I have been defcribing contained.

33	males.
1	female.
5635	working Bees.
3392	wax cells, for the ufe of the working Bees.
45	eggs.
150	Worms.
62	cells containing Bees bread.
236	cells in which honey had been laid up.

The End of the FIRST PART.

THE

THE

BOOK of NATURE;

OR, THE

HISTORY of INSECTS.

PART II.

A catalogue of the insects, which are referred to the second method of the third order or class of natural changes, called the Chrysalis.

I Now proceed to describe those insects which belong to the third order, as the preceding; but which present their several parts less conspicuously. For this reason, I judged that the present order of transmutations might be properly divided into two kinds or modes; though the one of them differ from the other only, as the schoolmen say, by accident.

Among those insects, which pass through the second method of the third order or class of transformations, and by force of the increasing and swelling limbs, and other parts, by which the skin is at length torn or burst open, assume the form of a Chrysalis, which exhibits to view all its parts, though more obscurely than they are seen in the Nymph; I reckon, in the first place, the diurnal or day Butterflies *, which are called Ulinders and Pennevogels by the Hollanders; and are distinguished also by two or three peculiar names of Albuli (Witkens), Papiliones Butyracei (Botercapellen), and Cerdonus (Schoenlappers).

Of these diurnal or day Flies, some are heavy and slow, others lively and swift; so that they cut the air, and move various ways. I preserve in my collection eighty-five species of those; among which, there are thirty-four foreign ones from Africa, America, Brasil, Spain, France, and elsewhere.

Among the day Butterflies beforementioned, there are twenty-two very large ones, thirty-three middle-sized ones, and thirty very small.

I preserve also some of their Worms or Caterpillars, several of their Chrysallides, and some of their Worms, which are partly Caterpillars, and partly Chrysallides. I can demonstrate, in the state of nature, in what manner the Butterflies are placed within their last skin; in which, when enclosed, we call them Chrysallides; and their parts, though still very minute, may be yet distinguished by their respective colours. I can shew how their wings begin to grow protuberant, after casting this skin. I likewise preserve separate the claws, intestines, stomach, and trunk of the Butterflies. I can likewise exhibit to the eye after what manner all the colours of the future Butterfly are seen through this skin, when the Butterfly is about to cast it, this being its last skin. I can also demonstrate all the parts of the Butterfly already in the Caterpillar. I pass over the mention of a great many other things worth observing, which I preserve, on this subject, there being now no time to enumerate them at large.

On a proper occasion, I shall explain the method by which Butterflies, with their wings at large, may be expressed and formed, in all their beauty, in plaister of Paris, without any colours. This I think an important piece of art, and it has not yet been described by any one that I know. I shall at the same time shew how Caterpillars may be filled with suet, with plaister of Paris, with air, and the like, and by this means be preserved. This is effected in none more conveniently than in the rough and hairy Caterpillars, the colours of which are permanent, as I can exhibit to the eye by several specimens.

* The Flies produced from Caterpillars are of two kinds, distinguished by the time of their flying abroad, and the form of their antennæ, or horns. They are called diurnal and nocturnal Butterflies, or more distinctly Butterflies and Moths. The Butterflies appear by day; and they have naked horns, terminated by knobs or buttons. The Moths fly only in the night, and their horns are feathery, and have no buttons at the end. The Fly represented Tab. XXXIII. Fig. VI. is a Moth, that Tab. XXXV. Fig. XII. is a Butterfly.

I ſhall likewiſe give the ſeveral methods whereby the wings of inſects may be variouſly expanded and diſplayed, in a form perfectly agreeable to that they have in nature. Upon this occaſion, I ſhall alſo teach by what means the wings of inſects, which are as yet hidden in their original folds, may be produced to light; and, when expanded, may be dried and preſerved at pleaſure.

If I further have leiſure and opportunity, I propoſe to deſcribe an art or management, to ſhew in what manner monſtrous and deformed wings are made to grow; and ſhall propoſe, with theſe things, various operations, relating not only to the accretion of theſe wings, but to the motion of the humours, which are conveyed through their veſſels. Finally, I ſhall alſo ſhew in what manner puſtules, tubercles, pimples, and the like irregularities, may be raiſed in theſe kinds of wings. I ſhall likewiſe ſubjoin many other, hitherto unheard of, curious experiments, which I hope will be uſeful to natural philoſophy, and to medicine. All theſe I am now obliged to paſs over with this ſlight mention, ſince they cannot here be treated of at large.

Whether or not the accurate Fabius Columna found out, with certainty, from the examination of the aliments, on which the Caterpillars, that are to be changed into Butterflies, live. What plants are like each other, in reſpect to their virtues? Is a queſtion worthy the inquiry. He tells us, that whatever different plants the ſame Caterpillar eats, are of the ſame nature and virtue. Other naturaliſts alſo affirm, that each ſpecies of Caterpillars has only one kind of nouriſhment ſuited to it; ſo that hence its own peculiar Caterpillar ſeems to be aſſigned to every plant on which we ſee them feed. From this, if it be ſo, it neceſſarily follows, that the different plants, which one and the ſame Caterpillar eats, muſt certainly agree in regard to their virtues; and many ſpecies of plants may by this means be conſidered, ſo far as medicine is concerned, as one. Others, on the contrary, deny the fact: nay, and experience itſelf teaches, as Mouffet very well obſerves, "That there are "a ſort of ſtrolling Caterpillars, which do not "ſuffer themſelves to be tied down to any "particular leaves or flowers; but boldly run "over and taſte all plants or trees, and feed "thereon at pleaſure." I have myſelf ſeen a Caterpillar, which eat the Braſſica, or Cabbage: likewiſe feed upon the leaves of a Mulberry-tree. I found it feeding on both, of its own accord. I ſtill preſerve alſo the egg of the Butterfly, into which this Caterpillar was changed. It is grooved or channelled, like an elegant piece of workmanſhip, and ſurrounded with a purple circle.

We ſee Aldrovandus has deſcribed one hundred and eighteen ſpecies of Butterflies, of the nocturnal and diurnal kind. Mouffet exhibits eighty-ſix. In the figures of Hoefnagel are found fifty. And the ingenious Goedaert, has given us deſigns of ſeventy-ſeven nocturnal, and eight diurnal butterflies. However, there is nothing to be found relating to theſe inſects in thoſe authors, beſide the ſimple metamorphoſis. Nay, Hoefnagel has given us only the figures. Goedaert has indeed deſcribed the Fly, hatched from the maggot found in cheeſe; but he explains it no further, than by a figure of the Worm, Nymph, and Fly; and he has given an inaccurate figure of the Worm.

But, what illuſtrious, what prodigious, what ineffable miracles of nature, preſent themſelves to the careful obſerver in the changes of theſe ſeveral inſects! It would have been much more uſeful, to have exactly, and according to nature, deſcribed only one transformation of any Nymph, for an example to be applied to all the reſt, than to have delineated the changes of all theſe Caterpillars, with their various colours, and their Nymphs: for, according to the other practice, the things which were moſt uſeful and neceſſary, remain untouched and neglected. I have, however, ſome reaſon to know, from my own peculiar obſervations before related, what may be done in this ſtudy; in theſe I have laid open, in ſome degree, the myſteries of nature, and clearly exhibited to view the adorable wiſdom obſervable in them. Indeed, if we ſeriouſly conſider what admirable phenomena remain to be further inveſtigated, and obſerved; and with what ſplendor, clearneſs, and beauty, nature exhibits herſelf in theſe inſects; and how ſwiftly, yet how regularly ſhe performs theſe great operations, we muſt own, certainly, that ſhe appears, as it were, to have expended the utmoſt ſtrength of her wiſdom on them, and to have no where ſo liberally, and clearly preſented her impenetrable and inexplicable miracles, to be viewed by thoſe who worthily ſtudy her works.

Whilſt the preceding ſheets were at the preſs, the incomparable anatomical obſervations of Dr. Marcellus Malpighius, profeſſor of phyſic and philoſophy, in Bologne, on the Silk-Worm, and its Butterfly, which the Royal Society of London, inſtituted to promote natural knowledge, cauſed to be publiſhed this year, 1669, were kindly ſent to me by the noble Thevenot, whoſe merit and zeal to promote natural knowledge, are ſufficiently known to all who happened to be at Paris, and preſent at the weekly diſputations inſtituted by him. And as the celebrated phyſician, juſt mentioned, ſeems to have attained, by his extraordinary accuracy, the end he propoſed to himſelf in theſe celebrated obſervations; we may particularly remark, that after that exact obſerver, Andrew Libavius, he is the only perſon who excludes the fancied metamorphoſis from the natural courſe of the changes, which the Silk-Worms undergo; and has publiſhed ſeveral things agreeable to truth: theſe, he confeſſes, became known to him by chance. I ſhall inſert his words, as being moſt true, and worthy of peruſal. "And at length, within four "days," ſays he, "in which time the heart of "the Silk-Worm continues moving ſlowly, "and the body is growing bigger, having

" thrown off the outward ſkin like a ſlough, " the Aurelia appears as a new creature. The " throwing off the old, and aſſuming this new " form, is completed in the ſpace of one mi- " nute and ten ſeconds; and it is thus done, " as I happened to ſee it. The motion of the " heart is very quick at firſt, and the whole " frame of the body appears convulſed; ſo " that the ſeveral circular folds of the ſeg- " ments emerge, and by the tranſverſe con- " ſtruction of the ſides, the external ſkin is " ſeparated from the inner; hence, upon " making an effort, and thruſting the body, " which now appears particularly thick to- " wards the head, the ſkin is driven back- " ward, and downward; and the portions of " the trachea, being ſeparated from their ex- " ternal proper orifices, are thrown away with " the ſkin, which is then caſt off. By this " motion, a cleft or opening is made in the " back near the head, and through the aper- " ture, the reſt of the body makes its way " out; the ſkin being, by degrees, drawn " back towards the fundament: This proceſs " is aſſiſted greatly by a yellow kind of ichor, " or fluid, which breaks forth from the cavi- " ties of the ſkull; and the Aurelia, or Nymph, " appears then free and diſengaged.

" Whilſt the inſect is making its paſſage " out, the horns, or antennæ, which are " thicker and more ſlimy than the reſt, are " ſeparated from the Aurelia's body, and are " torn, as it were, out of two cavities of the " ſkull, beyond the place where they are in- " ſerted; and their length, as they become " unfolded, occupies the ſame place, which " the two muſcles of the jaws formerly had. " The wings alſo, and the legs appear to be " circumſcribed in their limits; the wings are " drawn from their ſituation near the fore-legs " in the Silk-Worm; and the legs, from the " lateral parts of the back, which were before " of a purple colour. But as theſe unfolded " parts are yet mucous, they eaſily ſtick to " each other, and, inſenſibly growing dry, " they become ſo cloſely united, that the Au- " relia appears like one entire garment. Now, " as theſe parts are peculiar to the Butterflies, " and are deſtined for their uſe, the nature of " the Butterflies ſeems to be, to emerge ſooner " from the ſtate of the Worm, than is com- " monly believed, and to be earlier implanted " in it; for evidently in the Silk-Worm, the " beginnings of the wings, may be ſeen under " the ſecond and third ring of the body, before " the texture of the web. The antennæ, or " horns, are likewiſe delineated on the ſkull; " and the web being finiſhed, they have their " own termination; nor will it be improper to " doubt, that the new kind of life in the Au- " relia, is only a maſk or veil of the Butterfly, " which is already perfect within; intended " that it ſhould not be ſtruck or deſtroyed by " external injuries, but might grow ſtrong, " and ripen, as a fœtus in the womb." Thus far Malpighius, whoſe laſt-recited words anſwer to thoſe moſt evident experiments, which I have formerly exhibited to the noble Laurence Magallotti, when he was travelling through our part of the Netherlands, with his moſt ſerene highneſs the Grand Duke of Tuſcany, as I have before related. In this treatiſe I advance nothing particular concerning the Silk-Worm, except the figures of the brain, ſpinal marrow, and male organs of generation, which may be ſeen in Tab. XXVIII. fig. III.

Among the Butterflies which I have caught in the woods and fields, or on trees, flowers, and plants, and which I keep in my cabinet; there are ſeveral, which have been already deſcribed by Aldrovandus, Mouffet, Goedaert, and others: I ſhall therefore paſs theſe over, without enumerating their Caterpillars in this place. Among Caterpillars, ſome are hairy, others naked; ſome have tails; others have antennæ, or horns, ſpines, wreaths, ſpots, grooves, tubercles, tufts of hair, and, as it were, bruſhes; ſome are diſtinguiſhed by many, others with fewer colours; and a like difference is found in their feet. Some have heads like hogs, cats, and mice; others carry on them marks, as it were, of diſtinction; and ſome again are formed in different manners, and exhibit incomprehenſible repreſentations; ſo that they cannot be deſcribed by any detail of words; for which reaſon, Goedaert publiſhed them in their native colours.

In the mean time, whilſt we are conſidering the glittering beauty of the Butterflies, we cannot but declare, that the conſpicuous and beautiful tails of peacocks, and the ſhowy feathers of the Oſtrich, cannot be compared with the ornaments of theſe little creatures. Are not the wings of Butterflies moſt beautifully ſet, as it were, with pearls and diamonds, and with the turquoiſe, ſapphires, and rubies, which increaſe their ſplendor to ſuch a degree, that their baſe being made, as it were, of the ſubſtance of mother-of-pearl, and covered with plates of gold, ſilver, copper, or molten braſs, ſurpaſs the colours of the rainbow, by the bright reflexions of the rays? That theſe little creatures might be exalted to the utmoſt height of beauty, nature has favoured them with four wings, one of which beautifully repreſents the other, as it were, in a mirror or looking-glaſs; whereas they might have flown with only two, and that moſt ſwiftly, and have cut the air in infinite meanders, ſurpaſſing all imagination; as any one may ſee on opening the under pair of wings. Some of the Butterflies, which I preſerve in my cabinet, have oval, others round wings; ſome oblong, and ſome ſerrated; but, which is a very rare thing, one of them has wings on one ſide membranous, and on the other, only covered with the feathery or ſcaly duſt; ſo that they conſiſt partly of a bare membrane, and partly of one ſet with theſe feathers. I have likewiſe ſome, the lower wings of which terminate, as it were, in an acute tail; and in others they terminate in balls, or as if they had knobs on their tops: all theſe are diurnal. I proceed now to the nocturnal Butterflies.

In the next place then, we likewife refer to this order called the Aurelia, the nocturnal Butterflies, Phalænæ, or Moths. I preferve, and can fhew the curious, one hundred and ninety-three fpecies of thefe creatures; of thefe, thirteen are very large; twenty-eight of a middle fize; eighty-fix fmaller; and fixty-fix very minute. In this number there are thirty-five nocturnal, or night Butterflies; which, together with their refpective Caterpillars, and their changes, have been defcribed by Goedaert, and painted in their natural colours. I have likewife fifteen or fixteen fpecies of the Chryfallides; fome of which are naked or fmooth; others rough, having caft the hairs of their outward fkin; others are diftinguifhed with wreaths and various colours; others are colourlefs and naked; and others are, as it were, interwoven, and exhibiting a reprefentation through this web. I can likewife fhew many of the eggs of thefe Butterflies; fome of thefe are covered with hair; others furrounded with a kind of froth, and others again are hidden in other manners. I likewife preferve fome fingular and very beautiful webs, nets and membranes, wherein they enclofe themfelves, with the greateft circumfpection, and in a moft wonderful manner, when they are about to change: it is, indeed, hard to comprehend, how thefe little creatures can confine themfelves in fuch clofe and narrow prifons; and can, though completed or folded up in thefe, perfect their webs *.

The induftrious Goedaert has delineated fifty-feven fpecies of Chryfallides; but I am forry to fay, that among them all there is fcarce one accurately reprefented, as I fhall hereafter fhew beyond a doubt. Indeed, a great many things occur, occafionally, in the figures of Goedaert, which fhould be corrected.

It is certainly worth obfervation, that, as well by the night as in the day, we obferve innumerable living little creatures fluctuating in the air. This is not peculiar to the nocturnal Butterflies; for immenfe fwarms of Beetles, and very many fpecies of water infects, betake themfelves to the air after fun-fet. 'Tis for this reafon we obferve flowers, trees, fields, and gardens frequented, night and day, by innumerable infects, which feek for food upon them; that is, the great and fupreme Creator, whofe providential eye is always open on all created beings, appoints thefe creatures night for their day, and day for their time of reft, fince all things are at his pleafure, and in his power. If at night you carry before you a lighted torch, you will entice towards you many fpecies of fuch infects; and, when allured and deceived by the light, you may eafily catch them.

Among the nocturnal Butterflies, which I preferve, there is one, a Moth, the largeft that has been taken in Holland. It is produced from a very deftructive Caterpillar, with thin hair, which eats the bark, and even wood, of the Willow. This Caterpillar is called Spondyla rubra by Mouffet. I have fometimes fed it for a whole year on white bread only. Mouffet relates, that the largeft Moths kill with their wings, and afterwards devour, the fmaller kinds: but this, I have found, is contradicted by experience; for the Moths are provided only with a hollow trunk for their mouth. To which may be added, that many of thefe infects, as foon as they become fit for generation, entirely quit their former mifchievous difpofition, and, taking no food afterwards, apply themfelves only to propagating their fpecies. Indeed, fome do it more late, others earlier; according as their eggs become more or lefs mature, whilft they lie in the habit of a Nymph, nay, and in the Caterpillar-form. Thofe kinds muft be excepted, which have the care of feeding their young; for it is abfolutely neceffary, that fuch fhould be longer preferved alive alfo by nature, for the fake of their young. Thofe which are not obliged to rear their young, as the Butterfly kind in general, we obferve, die very foon after they are produced in their winged ftate. So that hence we fee, the whole change of thefe creatures is begun and finifhed by nature, with regard to their generation only; as is more evident from thofe fingular obfervations I have made on Bees.

In the Ephemeri, nature has ordered the bufinefs of generation in a different manner; for, as fhe has denied coition to thefe infects, the females are obliged to caft their feed into the water, in the fame manner as fifh caft their fpawn: this they do in the time when they beat and fly up and down on the furface of the water. On the other hand, the male Bees have air, inftead of water, into which they difcharge their fperm.

I preferve alfo that fpecies of Butterflies, which the celebrated John Bauhinus has defcribed in his treatife of hurtful winged animals, publifhed in French in the year 1693. I have reprefented the Caterpillar of this fpecies, the Chryfalis, and the Butterfly itfelf, in Tab. XXIX. Fig. I. II. and III. and have given it the name of Pernix.

I preferve likewife various fpecies of thofe nocturnal Butterflies, known particularly by the name of Moths, becaufe they are produced from worms of the fame name, that eat cloaths; and others that feed on paper, books, and duft, as well as the leaves of trees. Among thefe worms there are fome which, like Tortoifes, carry their houfes about them: this will appear in our fucceeding particular obfervations. Between thefe Moths and the other nocturnal Butterflies, which are called alfo by the fame general name, there is this difference, that the

* All that is required to produce the perfect Fly from the Chryfalis, is the evaporation of the abundant moifture; and this will happen in a fhorter time in hotter weather, and will require longer in cold Hence, the period of the fame fpecies lying in this ftate, is varied by accidents; and that of different fpecies, is alfo in its nature extremely various. Reamur has found, that eight days is fufficient for fome, and that others lie as many months.

former

former rise immediately, and suddenly fly into the air; but the others, before they can fly away, make a noisy and tremulous motion with their wings. This we observe also in other creatures, which, after they have rested some time, are obliged thus to prepare themselves for flight. I have given the true figure of the Tinea or Moth of cloaths, in Tab. XLV. fig. XXXI. to which is subjoined in fig. XXXIV. of the same Table, another kind of Moth, generated from a Worm that goes in its theca or case. And in Tab. XLIV. fig. XX. I have delineated a third Moth, produced from the leaf of an alder-tree. Finally, I have delineated the honey-comb Moth in Tab. XXVI. fig. II.

I can likewise shew in my collection that species of Butterfly, the male whereof is winged, but the female without wings: this privilege of the male is very singular and remarkable in this species. I have likewise observed, that the males of the Ants live free from labour, and have also four wings. Among the Bees the male has likewise this prerogative; it is discharged from all care of nourishing the young, and seems to be appointed by nature for generation only, not for nursing: it is for this reason probably that this creature's life is so short; and for the same cause we observe, that when the time of generation is over, these males are murdered by the working Bees. I preserve two kinds of males and females of the Butterflies, just now mentioned; the former of which have larger eyes than the latter: this we likewise observe in Bees, Ants, the Ephemeri, and other insects. The female of the Brasil Caterpillar that eats wood, is likewise without wings; this appears to me plainly, from its Chrysalis which I preserve in my collection. I have likewise a second species of Butterflies, whereof the male only is winged: It was taken in France; and I have represented it in Tab. XXXIII. fig. VIII.

I can in the next place shew some Butterflies, the wings of which are formed like feathers. Indeed we are to observe, that all the colours and different representations, which constitute the splendid pride of the Butterfly's wings, consist only of little feathers, differing among themselves with inexpressible variety of construction: this will be made manifest, when we shall treat of the manner, whereby those wonderful protuberances of the wings are formed in the Butterflies, and, with many other curious incidents, shall explain that most delicate increase of the wings. Finally, I can likewise shew the small Butterfly, which always flies in a straight line, having an oblong tail for that purpose; and therefore it does not, like other kinds of Butterflies, describe by its motion an oblique and unequal course in the air. Of this opinion is also the very learned Arnoldus Senguerdius, who, in his physical exercises, affirms, that the tail may have power to give an even, or uneven motion to those creatures. We add here,

An example of the second species or method of the third order of natural changes, which I call the Nymph-Chrysalis, or Aurelia, exhibited in that species of the nocturnal Butterfly, or Moth, whereof the male is winged.

TAB. XXXIII. No. I.

THE Caterpillar of this nocturnal Butterfly, or Moth, lying in its first coat or skin, which is called the egg-state, and is represented to the life. The first figure exhibits the egg magnified.

No. II. The same egg, or rather the hard or indurated shell of that egg divided into two parts. A microscopic delineation of this is again exhibited in the second figure.

No. III. The Caterpillar of this Butterfly having attained its full size, it is very worthy of regard, on account of its wonderful form. Behind its head are seen, Tab. XXXIII. No. III. *a.* four bundles of hairs, like so many cloaths-brushes, clipped even at the tops: these are of a white colour inclining to yellow. In the fore part, near the head, are also two prominent bundles of hairs, which resemble horns. These are hairs, *bb.* of a black colour, and consist of long, ragged, and uneven hairs; the tops whereof are adorned with a kind of branching feathers. On the two sides of the breast are seen, *cc.* two other feather-like bundles of hairs, placed very beautifully like oars. Just before these are placed, *dd.* two such other hairy oars; which, however, are much inferior in the beauty of their structure, to the second pair just now described, and are of a yellowish white, being almost of the same colour with the four former even-clipped brushes of the back. The whole skin of this Caterpillar is here and there beautifully variegated with fine colours, which are constituted, *ee.* by certain scaly and short-haired little feathers, among which, the longer and loose hairs are every where interspersed; whilst, in the mean time, the skin itself is observed to be of a bright red colour. At the hinder part of the body, this Caterpillar has a superb feather-like tail, which resembles the antennæ or horns of insects, in form and colour. This creature has sixteen feet; the six fore ones are placed near the head under the thorax; eight are placed under the middle of the body, and the other two at the end, just above the tail. These Caterpillars are found plentifully in the gardens of Holland, living among the leaves of plum and cherry-trees, and in several other places.

No. IV. This figure exhibits the manner, wherein this Caterpillar has wound itself up, *aaa.* and settled itself quietly in its web. It begins in that to be somewhat immoveable about the thorax; and it is to be observed, that it there becomes alſo thick, and more extuberant; for the limbs, which have increaſed there under the common ſkin, ſwell by degrees. This is particularly manifeſt, *b.* about the third and fourth annular inciſion in the fore part near the head. Before this Caterpillar caſts its ſkin, it becomes wholly deprived of motion; and in the place juſt mentioned is ſtill more conſiderably diſtended; and the body becomes ſhorter, becauſe the blood and juices are conveyed toward the breaſt from the hinder parts. I here likewiſe ſhew the manner wherein this little creature, whilſt it twiſted itſelf continually up and down in perfecting its web, has by that continual agitation worn off the greateſt part of its hairy feathers; and as they have fallen into the cavity of the web, hence is produced a little feather-bed, as it were, in which the Caterpillar lies the ſofter. To this may be added, that theſe hairs, lying looſely and ſcattered in the web, render the change of the ſkin much eaſier, and they are afterwards moved backwards with the ſkins from the fore parts.

No. V. I exhibit in this figure the ſame Caterpillar, when upon caſting its ſkin, it has aſſumed the form of a male Chryſalis, and ſhews all the limbs of the nocturnal Butterfly, that is to burſt from thence.

This repreſentation is more obſcure in the Chryſalis than in the Nymph; for the latter, as has been before ſhewn at large, in its proper place, very clearly diſplays to the eye the limbs of the little inſect to be produced from it, on caſting its ſkin. However, as the Chryſalis does really alſo exhibit to view all the limbs and parts of the future creature, and is, in reality, that very creature which it repreſents, I ſhall likewiſe exhibit theſe parts in this Chryſalis. The fourth and fifth figure anſwer this purpoſe.

No. VI. In this figure I repreſent the ſame Caterpillar, as it appears when firſt changed into a Chryſalis, and afterwards, after caſting its laſt ſkin, becomes a male nocturnal Butterfly or Moth. When theſe inſects have obtained this laſt form, they afterwards neither grow nor are at all changed, but are intent upon generation only; as I ſhall more clearly ſhew in the explanation of the following figures. In the mean time I ſhew the elegant antennæ, *aa.* which this male has, its ſmall body, *b.* and its four wings, *cc.* which the female has not.

TAB. XXXIII. FIG. I.

The egg of the nocturnal Butterfly, whereof we are ſpeaking, is the principal figure repreſented magnified: Its purple ring, and ſome little depreſſions and inequalities, whereby it is remarkably diſtinguiſhed from all other eggs, are ſhewn in this figure. This egg is alſo ſomewhat depreſſed in the middle, which makes it appear as if perforated and open in that part, when viewed without a microſcope.

FIG. II.

This exhibits the ſame egg broken into two parts, and forſaken by its inhabitant: for as it is covered with a hard ſkin, or ſhell, like a hen's egg; hence it is not rolled up, or drawn aſunder like a membranaceous integument, as is commonly the caſe in the eggs of Ants and Bees: it is on the contrary torn from the Caterpillar, which it before inveſted, in form of a jagged ſhell. This manner of ſeparation is not univerſal among all theſe eggs; for, according as the ſkin or ſhell is more or leſs hard, and the oppoſition great or ſmall; the deſerted ſhells are found to vary more or leſs from the form we have deſcribed. One may from thence ſee, after what various ways the inſects put off their firſt coats and ſkins, which may be eaſily illuſtrated by other examples.

FIG. III.

In the third figure I ſhew the method wherein theſe eggs are glued to the web. I ſhall preſently treat of this particular more at large. It is in this deſerted web ſeen alſo, what an hole the nocturnal Butterfly made, when about to creep out of the web.

FIG. IV.

In the fourth figure are repreſented all the parts of the male Butterfly in the Chryſalis itſelf; namely,

a. The two eyes in the head, under which, in the thorax, next between the upper legs, the trunk is ſituated.

bb. The antennæ or horns, with their integuments, removed from their natural ſituation, which is cloſe to the body.

cc. Six legs likewiſe removed from their places.

dd. The upper and under wings in their natural ſituation.

e. The rings of the body, in which are repreſented ſome hairs deprived of their ſkin: This is likewiſe the caſe, with reſpect to thoſe hairs which are ſeen on the head.

FIG. V.

All the before-mentioned parts are in this figure exhibited in the Chryſalis of the female Butterfly of this ſpecies; but theſe are not removed out of their natural ſituation. It is evident, by this figure, that the female Chryſalis differs in three reſpects from the male Chryſalis: firſt, as to the horns or antennæ; then in reſpect to the wings; thirdly, in regard to the ſize and thickneſs of the body; but theſe things will be made more evident, in the explanation of the ſixth figure. I muſt alſo call to mind here, that this compoſition or texture of the limbs, though various in the ſexes, yet never makes what is called, an eſſential difference between the Chryſallides of the various inſects, but only an accidental one, conſiſting in the ſhortneſs or length, or bigneſs and ſmallneſs of the parts. We muſt further obſerve, that this Chryſalis, and the inſect, which, upon changing its ſkin, is to ariſe out of it, do not in the leaſt differ from each other, except only in the order and diſpoſition of the parts, which are arranged in the Chryſalis, ſomewhat otherwiſe than they are in the perfect inſect, or the Chryſalis, after caſting its ſkin: This ſhould indeed be obſerved moſt carefully.

FIG.

FIG. VI.

After delineating, under No. VI. the male Butterfly, together with its moft elegant horns, its fine and flender body, and four expanded wings; I exhibit under the fame No. VI. all thefe parts, but much more imperfect; viz.

aa. Two uncouth horns or antennæ.

b. A thick and diftended body.

cc. Four fhort wings, or rather only rude portraitures of wings.

Hence it is evident, that it may be truly faid that this female has no wings. We may, for this reafon, fee all its fix legs without any impediment; though in the male they lie fo far under the wings, that only the two fore ones are occafionally feen between the horns and fuperior wings; as is manifeft under N°. VI.

In refpect therefore to this fpecies of infects, it deferves notice in what a wonderful manner the adorable Creator has eftablifhed diftinctions between the males and females; and what noble prerogatives he has given to one, and denied to the other, of them. Whilft beautiful antennæ, an agile and light body, and very fwift flying wings, raife the male to the thrones and fceptres, as it were, of kings; the female, being deprived of all thofe remarkable privileges, and fcarce able to bear the load of a fwollen, tumid, and thick body, feems to be condemned by the moft wife Nature, who has given fovereignty and dignity to the male only, to keep her neft perpetually, and take care of domeftic affairs. Hence it likewife is, that this female, like a moft prudent houfewife, never goes out of her habitation; but is always fixing the fruits of her matrimony, that is, her eggs, to the furface of the web out of which fhe herfelf crept; as may be feen in Fig. III. Indeed, this cuftom of faftening the eggs to the web in a conftant method, and, by the immutable law of nature, is fo peculiar to this fpecies of infects, that I have never hitherto obferved it in any other kind whatfoever. This female, therefore, affords a beautiful inftance of induftrious houfewifery; and, therefore, fhe deferves to be dignified with that name. The male, in due time, revifiting his female, and paying her the proper tribute of benevolence, fhews, in his fpecies, that he never deviates from the character of a chafte and honeft husband; fince he gives the affiftance of his excellence and dignity to the female, and fupports her weaknefs *.

FIG. VII.

The female is here reprefented, according to nature, fo full of eggs, that her whole belly is diftended with them; and as the integuments of this part is very thin, the eggs are diftinctly vifible through it. Nay, it is likewife feen how the fkin turns and infinuates itfelf round the convex windings of the eggs, and runs into the little fpaces between them; fo that it is like a clufter of grapes. In order to produce thefe eggs very clearly to view, the fkin needs only (Tab. XXXIII. Fig. VII. *a.*) be diffected in the belly and back, and raifed from the body towards the hinder parts; for then one may diftinctly fee after what manner they are placed within. Thefe eggs are found to be of a round figure, when taken out of the body; and have on the upper part, as I have already obferved, a purple ring: but, on the lower part, they are of a white glittering hue, like pearls. Their fhell or fkin is fo hard, that when they are dried in the air, they are not liable to break; and, therefore, the natural preferved fpecimens of them will be always agreeable to the perfon who fees them.

It is very remarkable in this creature, that, when it is yet in the condition of a Caterpillar, one may, even then, manifeftly fee in it the rudiments of eggs. Thefe, when the Caterpillar is changed into a Chryfalis, fhew themfelves much more diftinctly, and, having acquired their utmoft perfection, are at length feen thus elegantly in the Butterfly itfelf; that is, they feem watery in the Caterpillar: they appear in the Chryfalis, as it were, membranaceous and flexible; but in the infect itfelf they are hard, and refemble a real fhell, very little different from that of hen's eggs; and, for this reafon alfo, they will crack and break like an earthen veffel. From hence appears the reafon, why thefe eggs retain their figure, when dried; for this is the cafe, with refpect to all eggs that have a hard fhell: whereas the contrary obtains, in all thofe that have a thin and tender fkin; as may be feen in the eggs of Bees, and many other infects, which are almoft entirely deftroyed by drying them.

Before I conclude this hiftory, it may be neceffary to add fomething more concerning the parts of the Aurelia, that thefe may be the more appofitely compared with the parts of the Nymphs, and the difference between them underftood. When thefe and other Caterpillars are cafting their fkin, and prefenting their before hidden parts to outward view, in the beginning of this change we obferve them foft, tender, and fomewhat moift; and this is the cafe likewife about the parts of the Nymphs themfelves. But, a little after thefe feveral parts in the Chryfallides approach toward each other, they are then joined together; and indeed fo clofely, evenly, and equally united, that they reprefent, as it were, a continuous, fmooth, undivided, and varnifhed fkin. This is by no means the cafe in the parts of Nymphs: for they are not at all joined; but are only difpofed near each other in fuch a manner, that one may diftinctly fee each of them. This is the true difference between the parts of the Nymph and thofe of the Chryfalis.

* The progeny of the fame fpecies of Butterfly may, under favourable circumftances, be hatched at two feafons of the year; and confequently two generations, inftead of one, may be produced in one year. Reaumur has obferved, that the eggs of the Butterfly, which would be hatched in a few days if laid in fummer, will, if depofited in autumn, lie till the winter; and, unlefs the cold have been fevere, hatch the following fpring. The Butterflies produced in about fix weeks from the Caterpillars of thefe eggs, will lay their eggs in fo warm a feafon, that they will hatch, and pafs through all their changes into Butterflies the fame year.

The

The reaſon why the limbs in the Chryſalis unite, and are, as it were, glued and faſtened together, is, becauſe the ſkin, inveſting the Chryſalis in that part where the union or junction is made, is conſiderably thinner than where it is expoſed to the air. And therefore, on account of this inequality of the ſkin, it was abſolutely neceſſary to preſerve all the members from the drying air, and to defend them from injuries by their mutual compactneſs.

Theſe things are circumſtanced in the parts of the Nymphs in a contrary manner; for their ſkin is found to be equally thick in all the parts, ſo that it would be ſuperfluous to unite them together. But, even in Nymphs, ſome parts ſometimes occur, which are covered with an equal ſkin. This holds chiefly when ſome parts reſt upon or are ſupported by others; and it is obſerved principally about the caſes of the wings, which have a much thinner ſkin, where they receive the wings, than where they are turned to the air: therefore, in this reſpect, they entirely agree with the Chryſallides.

It certainly deſerves great notice, how delicate and thin the integuments of thoſe parts are, where they are found to lie on each other: and hence even the continued ſkin, which covers or incloſes theſe parts, has its external part thick, and is ſtrong and hard; but in the internal part it is thin, tender, ſoft, and formed like a ſpider's web. This ſkin ſometimes alſo is ſo fine, that the rays of the ſun exhibit therein various colours to the eye, eſpecially where it is in any degree folded: as is obſerved in very thin and fine blown glaſs, and in the ſlender filaments of a ſpider's web.

This being well conſidered, it is eaſy to underſtand why many Butterflies are produced deformed; that is, when their limbs, under the period of the tranſformation, are not well united together, as frequently happens. Indeed I have, more than once, ſeen that they have dried and periſhed, by reaſon of this defect of a proper union. The ſame effect may be performed by art, and a certain operation: I mean, we may thus produce Butterflies that are deformed. I can alſo very eaſily diſunite all the limbs of the Chryſallides; for, naturally, theſe parts in the Chryſallides will then never ſeparate themſelves further, not even at the time they are ſtripped of their ſkin: for the ſkins to be cut off from thence, have only three or four cracks or openings, ſince the thinner ſides of theſe inveſting parts are then very eaſily broken further, with the leaſt motion; ſo that there will be no need to move the reſpective limbs out of their places.

As thoſe who ſearch into the ſecrets of nature have not obſerved this, I am therefore inclined to think they have imagined, in conſequence of this overſight, that the continued ſkin of the Aurelia conſiſted of a texture of the parts united one with another. They have therefore fancied, that the inſect lies in that uniform and undivided ſkin, in the ſame manner as the chicken lies in its undivided ſhell. But this is contrary to all truth; for every part of the Chryſalis, as well as the limbs of the Nymph, is inveſted with its reſpective integument. And this is the more inconteſtably certain, becauſe theſe limbs, together with the ſkin wherewith they are ſurrounded, are found entirely perfect in the Worms and Caterpillars, and may be even there ſeparated or diſengaged; ſo that one of theſe inſects is, in reality, always in another: as I ſhall hereafter deſcribe, and abſolutely prove.

Another remarkable thing in theſe Aureliæ, whereof we are ſpeaking, is, that even the hairs of the Caterpillar caſt a ſkin, and are afterwards ſeen in the Chryſalis. And hence ariſes another invincible argument, moſt clearly demonſtrating, that the Aurelia is not a creature newly transformed, but is really the former creature, which has caſt its ſkin. The whole change, or rather accretion of the parts and limbs, conſiſts indeed only in this, that the inveſting membranes or ſkins, which are ſo many veils that obſtruct the ſight, are removed by degrees, and thrown off; ſo that the limbs, which, from the firſt, lay hidden in the inſide, are, in the end, ſeen on the outſide. In all theſe changes, nothing is more wonderful than the motion by which alone they are ſeverally produced, and perfected by means too difficult to be inveſtigated. The deeper we here look into nature, the more we are obliged to confeſs our blindneſs, and our ignorance. Indeed, there is nothing more true, than that all theſe things, which I advance and publiſh, are no more than the naked ſhadows of the inexplicable myſteries of the Great Creator: the internal nature, and true diſpoſition, of theſe meanders are above the reach of our limited underſtandings.

I ſhould never conclude, if I attempted to proſecute minutely all the wonderful things that occur in theſe Chryſallides: and, indeed, I ſhould weary out the reader's patience by a prolix recital of them; ſince he muſt firſt have ſome knowledge of the hiſtory of theſe inſects, who would properly underſtand what is delivered. I ſhall add but one thing more concerning the eggs of theſe inſects: this is, that as the rudiments of theſe eggs may be perfectly ſeen in the Caterpillar, there ariſes from thence a ſtill more powerful argument to prove, that there is no real metamorphoſis or change, or real transformation of parts in the creature; but only a ſimple growth, or accretion, as in all other animals; only, that it is more conſiderable, and more admirable, than in the other creatures. I ſhall alſo add, that the egg itſelf is, in reality, no other than a little inſect, the ſtrength of which, by degrees, increaſes in its ſkin or coat; until it has at laſt acquired ſufficient ſtrength to break through this ſkin or ſhell, and caſt off its firſt integument. It is therefore, from what has been ſaid, clearer than the meridian ſun, of what infinite uſe ſuch experiments are to us; as thoſe I have propoſed, by way of ſpecimen, at the end of the third chapter.

In the webs, which Caterpillars form, there is obferved a wonderful variety; for as they ferve them in the place of nefts, every Caterpillar, according to its peculiar nature and difpofition, forms and perfects its web its own way. Though thefe webs are conftructed with wonderful art, yet thofe Caterpillars, which are enclofed in no web, excel all others in art and invention. Some of thefe, which bury themfelves under the earth, are inftructed to make caverns or holes in it fo artfully, that they feem to have a more fecure habitation there, than others in their walls. Some others, that remain above the earth, have the art to fix their webs with fuch ftupendous dexterity to plants, trees, walls, and in hedges, that they fafely hang with it, though expofed every way to the furrounding air; and are at length changed, after cafting their fkin, into very beautiful Butterflies. It is moft wonderful, that thefe little creatures, at the time of their change, know how to difengage their claws from the web, and to change the fkin of thefe their fmalleft parts, together with the feparating exuviæ; whilft, at the fame time, they remain fixed by thofe claws in the web. Indeed, in this art, the Caterpillars by far excel the moft active of the human fpecies in their gefticulations. I have likewife feen fome Caterpillars, which knew how to bite off a certain part of the leaves of trees; and, as in a fafe habitation, afterwards have enclofed themfelves therein, by the help of the threads they have fpun. Others weave oval nefts; others exactly round ones; others oblong ones; others make them channelled; others fuch as are like a delicate network; others angulated; fome weave into their work wood, fand, fhells, ftones, and other matters: others fimply, tho' very artfully, roll themfelves up in the leaves of plants and trees. In a word, the wonderful ingenuity of Caterpillars is manifefted in a thoufand inventions; and in all of them the hand of the Great Creator is moft clearly feen, who has infufed fo much prudence, as it were, and wifdom into thofe creatures, exhibited in order, weight, and meafure.

I have particularly treated of the Butterflies hitherto defcribed in the third chapter of this work; and I have fhewn there, that the induftrious Goedaert, in Part I. Obf. 59, and Part II. Obf. 30, has given a fhort defcription of them, and exhibited their figures; though he did not perfectly know thefe creatures, nor could diftinguifh the male from the female.

FIG. VIII.

I have found thefe creatures, here treated of, not only in our part of the Netherlands, but alfo in France; but they were of a different fpecies. This will appear by the eighth figure, wherein I reprefent thefe infects in the act of coition. The female of this fpecies is abfolutely without wings, (Tab. XXXIII. Fig. VIII. *a*.) and has two fhort horns, fix legs, and a body divided into feveral rings. The male, on the contrary, is exhibited with two beautiful horns and four wings, *b*. and with a body fomewhat larger than that of the Holland Butterfly, delineated under N°. VI. Thefe were alfo nocturnal Butterflies; but their bodies were more fwollen than thofe of Holland; the male whereof is diftinguifhed for its fmaller body and fmoother wings. Thefe French Butterflies are variegated with a gray and blackifh colour, mixed with white. This mixture renders them very beautiful. The divifions of the back are tinged with a browner black; and there are, moreover, obferved fome yellowifh rings in that part, confifting of hairs. From what Caterpillars thefe Butterflies are produced, I do not know. I found them in a field in the act of coition; fo that, from thence, I could affirm for certain, that the male and female are the two fexes of the fame fpecies.

The remarkable neft, which I have delineated in the hiftory of the Ephemerus; firft publifhed feparately, and which I proved at the fame time to be conftructed of fmall bitten pieces of wood, laid together, and joined like the beams of houfes in Ruffia; this neft, I fay, is built by the wood-eating Caterpillar, which inhabits it, and carries it about on its back in form of a pyramid. Thefe Caterpillars are likewife changed into a winged male, and a female without wings. This appeared very evidently to me, when, upon opening the neft, I found the Chryfalis of the female and the Exuviæ of the Caterpillar in it. Therefore, feveral pairs of little creatures feem to exift in nature; the males of which have this peculiar privilege above the females. It likewife appears from thence, how much the infects of one and the fame fpecies may differ from each other. Perhaps the fame thing likewife holds in fome quadrupedes, birds, or fifhes; particularly in thofe fpecies, the males or females whereof we have not yet been able to diftinguifh. Some fay, the Snake has no difference of fex, which others again deny. I cannot prefume to decide this controverfy, as I never took any particular pains about that fubject.

The anatomy of the common diurnal and variegated Butterfly.

THE INTRODUCTION.

THE hiftory I am about to give, under the fecond mode of the third clafs or order of natural changes, is fo amazing in all its circumftances, that it might very well pafs for a romance, were it not built upon the moft firm foundations of truth. Facts alone fupport it; fo that, how much foever our comprehenfion may fall fhort of the things to be related, we muft affent to them notwithftanding; and we fhould ftudy them alfo, as fome of the moft fhining miracles of God's power and goodnefs.

In this hiftory we fhall fee moft furprifing changes in the limbs of thefe infects, growing under one another, that anatomy has ever difcovered; fuch changes, indeed, as no human wit could contrive, or could even think of, had not God, the great Author of thefe wonders, been gracioufly pleafed to reward our induftry with the difclofure of them. In this hiftory we fhall behold a poor and wretched infect lofe by degrees all motion, and, in appearance, ftand configned to death and the grave; in which feemingly hopelefs condition, however, all its former limbs acquire an extraordinary degree of perfection, till, at laft, rifing from the fepulchre in all the gaiety and magnificence of the richeft ornaments, and moft refplendent colours, it no longer continues a reptile, creeping upon the earth; but, foaring into the air, changes its flow and heavy pace into the moft nimble and unreftrained flights.

This creature, in its painful and humble ftate of life, fupports itfelf with crude and undigefted food; and, ordinary as this refrefhment is, the infect is obliged to earn it with much labour and danger: but when freed from the jaws of death, and after paffing through a fecond infancy, the pureft nectar becomes its portion, and the air its element. It raifes itfelf boldly toward the fkies, and roves at pleafure from meadow to meadow, and enjoys, without care or concern, the exquifite juices which bounteous nature has prepared for its ufe, and prefents it from the unfullied cups of the moft fragrant and beautiful flowers.

It has now put off its old body; and the entrails, which were before fupplied with coarfe food by the painful operation of the teeth, and which digefted this food by a violent trituration of the ftomach, are become more tender, delicate, and fine, fo as only to fuit a more pure and elegant aliment: and often the happy creature is enabled to live feveral months fucceffively, without the leaft want of nourifhment.

To fum up all thefe wonders in a few words, the creature, that heretofore crept upon the earth, now flies freely through the air; fips its food, inftead of chewing it; and, far from creating our averfion by its frightful prickles, and foul appearance, it attracts our admiration by the moft elegant fhape and cloathing; and from being fcarce able to move upon the humbleft fhrubs, acquires ftrength and agility to tour in its lofty progreffes, far above the talleft inhabitants of the foreft.

All thefe furprifing, and indeed almoft incomprehenfible changes, from indigence to affluence, from contempt to glory, from labour to eafe, will be amply defcribed in the following hiftory, and every one may eafily underftand how they can happen, and are actually effected.

By comparing thefe ftrange viciffitudes with the wretchednefs of our own prefent life, our death, and refurrection; and examining likewife the caufes of our mifery, and the beft methods of fubduing, and even eradicating in ourfelves, the latent feeds of decay and deftruction, in order to prepare our fouls and bodies for a glorious refurrection; we fhall, befides the moft innocent and becoming pleafure, reap very confiderable and lafting advantages, by being powerfully excited to praife God, without intermiffion, as he deferves, from thefe furprifing effects of his wifdom and power, now clearly laid open to our infpection.

CHAP.

CHAP. I.

A description of the external parts of the Caterpillar, and a dissection of the internal, so as to give a satisfactory account of the blood, muscles, kidney-shaped parts, stomach, gullet, intestina cœca, or closed guts, silk-bags, fat, pulmonary tubes, heart, brain, and nerves.

THERE are a great number of Caterpillars that become, after their change, diurnal or day Butterflies, that are found feeding on nettles, with which they support themselves; sometimes devouring that plant to such a degree, as to leave nothing but the stalk remaining. It is of these I intend to speak in this place. They are very common in Holland, during the summer months. The skin of this insect appears thick set with very sharp prickles, Tab. XXXIV. Fig. I. *a*. At its full growth, it is almost an inch and a half long. It is of a deep brown colour, except on its sides, which are of a yellowish green, something inclining to white. These Caterpillars differ so much from each other in this respect, that, in point of colour, it is impossible to describe them distinctly. This little insect has six legs on that part of the body which is next its head: of these legs, I have here delineated only the three that belong to one side, *b*. The middle part of the body is furnished with eight legs more, four on each side, *c*; besides which there are two others that spring from the division forming the tail, *d*. That the construction of this Caterpillar may be the more perfectly understood, I shall represent it as it appears, somewhat magnified by a microscope. Thus we shall see, that, counting the head a tail, it is composed of thirteen annular divisions, Fig. II. 1, 2, 3, 4, &c. The head is of a horny substance, or like bone, and of a shining black colour; and, here and there, it is covered with a kind of hair like bristles. On each side of the head are six black eyes, *aa*, and under the eyes the antennæ, *bb*. There is a lip on the lower part of the division which constitutes the head, and under and near the lip are placed the teeth, *cc*. Near the teeth are three little protuberant spots, the middlemost of which is a nipple, or papilla, *d*, from which the Caterpillar emits a kind of thread; which will be hereafter considered.

There are some bristly hairs on the second ring, and under these hairs is a black spot, above the first pair of legs. This is the first of the puncta respiratoria, or points of respiration, by which the insect breathes. The legs, *e*. consist of various joints, composed of a bony or horny substance; and each is terminated by a claw of the same substance, and of a deep red colour. There are no openings for respiration on the third and fourth rings, as well because the wings of the future Butterfly lie against those rings under the Caterpillar's skin, as because such breathing-holes would greatly obstruct the motion of the limbs. The third ring has on each side two sharp and bristly hairs, which, at some distance from their roots, produce many others. The two lower of the original hairs, which are likewise the least, are of a white, and the two upper ones of a black, colour.

The fourth ring is of the same form with the third; but as I have represented it a little sideways, there appears on it only one pair of bristles. The legs, Tab. XXXIV. Fig. II. *fg*, placed on both these rings, resemble exactly those of the second ring. Between the hairs already mentioned, there are others, which I have been obliged to omit in the figure I have given, for fear of rendering it confused. These last hairs are white, and they spring from whitish spots in the center of a black ground.

On each side of the fifth ring there are three bristly hairs, with one exactly on the middle of the insect's back, *h*. The first and largest pair of these hairs, *i*, lies a little slanting, on account of the single hair on the middle of the back. The second pair, or that next to the first, rises over the points of respiration; and the third pair, *k*, under those points, on the declivity of the belly. I have, to avoid confusion, omitted the lateral prickles; but have represented the others just as they appear, covering almost every ring of the body. The rings that follow, all to the thirteenth, are exactly of the same form, with breathing-holes in every one of them; so that the insect has no less than eighteen of these openings disposed along its sides, with a blackish edge or border to every hole.

The fifth and sixth rings have no legs annexed to them; but the seventh, eighth, ninth, and tenth have each a pair, springing from the lower part or belly of the insect. These legs are covered with a fine membrane, consisting of many joints, and are armed with little red claws, *llll*, set round the extremities of their legs.

The eleventh and twelfth rings are likewise without legs. The only pair, in this part of the insect, springs from under the tail, *mm*. The ring, constituting this part, has but one pair of sharp hairs.

The

The anatomy of the Caterpillar.

HAVING thus fuccinctly defcribed the external conftruction of this Caterpillar, I am now to exhibit and demonftrate its internal parts. The firft thing that prefents itfelf, on opening the back of this infect, is the blood, which flows freely from it. This is of a tranfparent green, and may be made ufe of as a paint for that purpofe; though, as it dries by being expofed to the air, it lofes much of its original luftre, and by degrees turns yellowifh. There next appear, immediately under the fkin, the mufcular fibres, which ferve to move the rings of the body. On raifing of thefe fibres, the fat appears, as likewife the heart, known by its panting motion: this I fhall prefently defcribe. On the hinder part, upon the back, and between the laft rings of the body, there are two fpots or particles, with fome divifions in them, Tab. XXXIV. Fig. III. not unlike the kidneys of men or quadrupedes. On opening thefe fpots, they are found to contain fome veffels, and to have a connexion with the lower rings, by means of fome flender filaments, and certain pulmonary tubes. In my opinion, thefe particles do not attain their full growth and perfection, till the infect becomes a Butterfly. This appears plainly enough in Silkworms, whofe tefticles fpring from this part. I fhall therefore referve what more I have to fay, on this fubject, for my defcription of the Butterfly, as they appear only in an embryo-ftate in the Caterpillar.

Removing the parts already mentioned, we come at the ftomach. This almoft entirely fills the Caterpillar's body; and, though it be fo very capacious, is always as full as it can hold, the infect being extremely voracious, fo that it hardly ever defifts from eating a fingle moment. During this part of its life, it feems entirely confined to the two operations of taking in its food, and difcharging its excrements; by which means it acquires its proper fize in a few days. The gullet, Fig. IV. *a*, is a fmall and flender tube, which running from the forepart of the ftomach to the mouth, through a flit in the fpinal marrow, juft under the brain, and growing larger and larger in its progrefs, it forms a communication, for the infect's food, between the mouth and ftomach. I have reprefented only a few of the pulmonary tubes, *b b b b*, in the forepart of the ftomach, where they appear like fo many veffels, elegantly difperfed over its furface, and fupply it with the vital air from every fide. Amongft thefe tubes is to be feen a tendinous ligament, *c c*, which runs, both above and below, from one end of the ftomach to the other. It arifes from the tendons of the mufcular fibres belonging to this part. Thefe mufcular fibres are feen diftinctly through, and I have reprefented them on each fide of the ftomach, *d d d*; but, to avoid confufion, I have been obliged to leave out the pulmonary tubes, that are to be feen in the infect in the fame place. The ftomach confifts of three coats. The outward coat, upon which the pulmonary tubes are diftributed, is very thin: the next is thicker, and mufcular; the third, which immediately contains the fubftance that is to be digefted, is very delicate like the firft.

On the upper and lower parts of the ftomach are placed fix clofed guts, which, defcending towards the thick gut, there terminates in little tubes, that have no paffage. Thefe fix little guts, which are here reprefented out of their natural fituation, by returning upon themfelves, and running back towards their origin, form, as it were, twelve inteftines; fo that, on parting them from the ftomach, and difpofing them orderly along its fides, there appear fix on each part. Thefe little guts arife on each fide, from a trunk, in form of a knot, Tab. XXXIV. Fig. IV. *f f*, which fprings from the inteftine that immediately fucceeds the ftomach; and then again, being divided into fix tubules, thefe run back towards the thick inteftines, *g g*, againft which they are folded and curled in a moft furprifing manner, *h h*. One of the thick inteftines, *i*, in which the excrements are reduced to form, is here reprefented alfo; and this thick inteftine ends in the rectum, or ftraight gut, *k*.

On removing the ftomach, there appear very plainly two little canals, Fig. V. *a a*, which before had feveral windings, and lay againft the fides of the ftomach. Thefe canals afcend to the forepart of the head, where I traced them very high, as far as the brain; but could follow them no further, fo that I cannot affign their abfolute origin. On the forepart they are very fine and flender, *b*; but afterwards dilate greatly, *c*, till at laft they terminate in two fharp filaments, *d*, which have their infertion near the cœca, or clofed inteftines.

It is no eafy thing to determine the ufe of thefe little parts from the diffection of the Caterpillar: to pretend to guefs at it, would be folly. Our bufinefs is to find out the intentions and operations of nature, not to contrive them. At firft, I took thefe for the filk-bags of the Caterpillar, on account of their great refemblance to thofe of the Silkworm. But I was afterwards convinced of my miftake, by finding them unaltered in a Caterpillar, that had made its web. This circumftance may ferve to convince us, that they muft be of fome ufe to the future Butterfly.

The real filk-bags of the Caterpillar are not more than one fourth part fo large as the veffels, which at firft paffed upon me for fuch; for the Caterpillar fpins but very little; and I have therefore omitted, as not much worth notice, the repofitories of the matter with which nature has fupplied her for that purpofe.

After the foregoing parts have been examined, the fat becomes confpicuous. This fubftance, ſubſtance, in a manner, takes up all the inſide of the Caterpillar, not filled by the ſtomach, the head and tail not excepted. It is of a yellowiſh colour; but here and there inclines to white. As to its form, it looks like a congeries of little membranes, folded one over the other; but differing greatly in conſtruction and texture. The fat ſerves to this amongſt other purpoſes, that it binds and ſupports the pulmonary tubes, which are diſtributed through it in great numbers.

The pulmonary tubes ariſe from three remarkable pairs of branches, which are ſeen on each ſide in the breaſt, belly, and tail of the Caterpillar; and the pulmonary tubes, propagated from every part of theſe branches, communicate with each other at every one of the points of reſpiration. In theſe parts alſo are to be ſeen a great many ramifications of pulmonary tubes, which ſpread themſelves all over the body, ſo that no part of it can be aſſigned, not even any of its horny ſubſtance, that is not furniſhed with its pulmonary tubes.

The beſt way to ſee the heart, Tab. XXXIV. Fig. VI. *a a*, of the Caterpillar, is by laying it on its back, and then opening the belly. It is then found, that this organ extends from one end of the body to the other. It pervades the tail, belly, and breaſt; and thence ſtretches very high up to the brain itſelf. This heart is an oblong, delicate, and ſlender little tube, which widens in ſome places, and again grows narrower in others. It is furniſhed with ſome pulmonary tubes, and with ſome muſcular and fibrous hairs, which run part lengthways, and part croſſways, and require a great deal of art and induſtry to diſcover them. This tube contracts itſelf by the help of its own fibres, and is dilated again by the joint efforts of a prodigious number of muſcles, *b b b b b b*, of a ſingular form, which grow on its outſide; and, though eaſily ſeparated and diſtinguiſhed from one another, they look, at firſt ſight, as if they were but one continued muſcle. The deſign I have given, to illuſtrate the deſcription of this organ, repreſents only a part of it.

It is no eaſy taſk to get a ſight of the brain and ſpinal marrow in healthy Caterpillars, on account of the great quantity of fat that involves theſe parts; ſo that ſickly inſects, or thoſe which have been otherwiſe waſting for ſome days, with conſtant labour, are the fitteſt for this purpoſe. The inciſion muſt be made in the back, as the brain and ſpinal marrow lie in the abdomen. The brain is compoſed of two hemiſpherical lobes, Fig. VII. *a*, placed juſt over the inſertion of the gullet into the mouth; and under theſe lobes are to be ſeen the heads of the ſpinal marrow, compoſed of two nerves, *b b*, which unite at ſome diſtance, and form the firſt knot or joint, *c*, from whence nerves are diſtributed to the muſcular parts of the head. The marrow then parts again into two branches; and the nerves, *d d*, ſpringing from thoſe branches, are diſtributed amongſt the muſcles of the neck. Another conjunction of the main nerves forms the ſecond little knot or joint, *e*, which is ſomewhat leſs than the firſt. From this ſecond knot or joint iſſue two branches, as from the firſt; and theſe branches unite again, to form the third joint or knot, whoſe ramifications are diſperſed amongſt the muſcles of the thorax. Here the marrow divides itſelf again for the third time, and runs in this divided form a conſiderable length, *f*, before it coaleſces into the fourth knot or joint, *g*; to which ſucceeds, after a ſhorter ſeparation, the fifth, *h*. Theſe laſt joints or knots ſupply with nerves the muſcular parts of the embryo legs and wings of the future Butterfly. After this, the marrow parts no more; but it has however ſix more joints or knots, beſides thoſe already taken notice of, making eleven in all; of which the ſixth *i*, the ſeventh *k*, the eighth *l*, the ninth *m*, and the tenth *n*, emit each four nerves, all diſperſed among the viſcera and the muſcular parts of the abdomen. Finally, the laſt knot, *o*, beſtows all its nerves upon the tail.

CHAP. II.

The manner in which the Caterpillar is changed into a Chryſalis or Aurelia, with the true explanation of what the Chryſalis is. This chapter contains alſo ſome anatomical obſervations, and ſome other curious remarks concerning the Chryſalis and Butterfly.

WHEN the Caterpillar has fed ſufficiently, it reſts for ſome time. In this period, all the food it has taken is thoroughly digeſted. It then forms a pretty ſtrong web upon the ſtalks or leaves of the plant whereon it fed: but this web, on account of its great delicacy, is not eaſily ſeen; unleſs the inſect be put into a little box, with a piece of black paper for it to work on. Then its web, however ſlight and tender it may ſometimes be, ſhews itſelf very plainly. This web being finiſhed, Tab. XXXV. Fig. IV. *a*, the Caterpillar ſtrikes into it the claws of the two legs under the tail, and afterwards forces in the tail itſelf, by contracting thoſe claws, and violently ſtriking thoſe legs againſt one another: and, as ſoon as the tail is thus well ſecured, it lets itſelf hang in the air, with its head downwards, by looſening the hold it hitherto kept of the plant with its other legs.

But I think it proper to deſcribe the limbs of the Caterpillar, that grow under its ſkin, before

I proceed any further in shewing how it throws this skin off; for it is necessary to know these particulars, in order to acquire a true and just idea of the nature of the Aurelia. This, indeed, is no more than a beautiful and orderly external representation of such limbs of the Caterpillar as have grown under its skin: for though the limbs, now mentioned, may be seen under the insect's skin, at the time it crawls and eats in the form of a Caterpillar, nevertheless it is, in this state, on account of their extreme tenderness and delicacy, a very difficult matter to have a satisfactory view of them. They are, in a manner, as fluid as water; and they lie folded up in many very tender membranes, interwoven with pulmonary tubes. The best time to obtain an elegant view of them, is when the Caterpillar is just about throwing off its skin, and exhibiting to open view the miraculous operations of nature, which it hitherto concealed.

By stripping the Caterpillar of its skin at this period, we may perfectly gratify our curiosity in this respect: we may then plainly perceive, that it has two antennæ or horns, Tab. XXXV. Fig. II. *aa*, and the two shanks of a trunk, *b b*. There are also visible two sharp protuberances, *c c*, which may be very well called the forks, or furcillæ of the future insect, on account of their great resemblance to those parts. The eyes, *dd*, shew themselves also, under these protuberances; and a little backwards, in the thorax, are four wings, *ee*. These lie in folds under the skin, like all the other parts, so that they may be considerably extended. Near these wings there appear six legs, springing from the thorax: these have changed their skins. All the other ten legs, with their integuments, have now been thrown off, with the common skin; of which, as already observed, it is necessary, upon this occasion, to strip the insect. The same happens to the sharp-pointed hairs that grow on the Caterpillar's back; but these last leave very considerable marks behind them. Lastly, the other rings of the body, *ff*, and the tail, *g*, shew themselves in their proper places.

Having duly attended to the foregoing particulars, and fixed them deeply in our memory, as the foundation on which it is intended we should build all our future inquiries; the next business is to observe, how wonderfully all these parts are placed and distributed under the skin. But here I must observe, that they do not naturally lie in the same order and manner in which, for the sake of perspicuity, I have represented them; so far from it, that the extremities of the four wings are enclosed in the same skin with the four hinder legs of the first series; and the horns, trunk, and furcillæ, are folded and laid up within the skull in a most surprising manner.

These little horns, or antennæ, are fixed by an articulation, Fig. III. *a a*, to the forepart, at the base of the head, where they form some windings and turnings under the skull near the eyes, and against the base of the trunk; to all which parts they are fastened, by means of a great many membranes full of ligaments. This is their natural situation; from which I have been obliged to deviate in my delineations, the better to exhibit the other parts which they cover, and likewise because I cannot now spare the time requisite to make two drawings, which it would be otherwise necessary to give. The proboscis, or trunk, Tab. XXXV. Fig. III. *b b*, is folded up also in a surprising manner, and placed in the forepart of the skull; but here I represent it as drawn out a little. The forks, or furcillæ, likewise, *c c*, are plaited and folded up. Under these forks lie the eyes, *d d*. We may perceive, in the middle of the head, that portion of the skin which lies under the middle of the skull, *e*, and there joins the root of the trunk or proboscis, *f f*. Between the foldings of the proboscis appear two small parts, lying against each other, *g*. These are called furcillæ in the Butterfly, because the trunk, when curled, hides itself between them, as between the two tines of a fork. All these things are so wonderful, that I have thought it best to represent them larger than the life.

The particulars here named, being rightly understood, the change, or, to express myself more properly, the growth of the creature from the Caterpillar-state into an Aurelia, cannot but appear plain and intelligible; for the whole operation consists in this, that the Caterpillar casts its skin, and shews the parts which hitherto lay concealed; unfolds its limbs, and arranges each in its right place with great regularity and order. This is the whole operation, to which so many authors have substituted a monstrous metamorphosis, or absolute change of one creature into another, not to be found any where but in their own misguided imaginations. What wonder then, if, in their vain and idle attempts for some hundred years past to explain this metamorphosis, they should have met with no success? Thus it is, that we are apt to err, when, depending too much on our own reason and imaginations, we sit down contentedly in our studies, and feed ourselves with our own weak fancies, instead of looking for truth into the magnificent works of the Creator, though such inspection alone can give us just notions of what we desire to know.

There is no difference between the Chrysalis and the Caterpillar, but that the former lets us see more plainly the limbs and parts of the future Butterfly, notwithstanding the skin, which yet encloses them. For as soon as the Caterpillar has finished its web, Tab. XXXV. Fig. I. *a*, and has fixed in it, by means of its crooked claws, the hinder part of its body, it lets itself loose, and hangs head downwards, as already mentioned, contracting itself almost into a semi-circular form. In this condition the creature grows shorter, and smaller, by degrees; and this indeed so sensibly, that the eye may easily trace its progress: for the third and fourth annular divisions of the body, *b*, are so remarkably swelled and expanded at this time, by the blood and air that dilute the enclosed wings and legs, that the reft of the body, drained of its juices, muft of courfe become proportionably fhorter. The fame alterations take place in the trunk, the forks, the eyes, and horns; all which equally fwell and expand themfelves, and endeavour to make way for their laft increafe.

By the time the Caterpillar has hung in this manner fifteen or eighteen hours, it fo entirely lofes the power of all its fixteen legs, as not to be able to make the leaft ufe of them to crawl, or ftand. The rings of its body then begin to move up and down, in a very fenfible and furprifing manner. Then the eight legs, *c*, in the middle of the body, grow lefs and lefs by degrees, caft their fkins, and are turned towards the tail, Fig. IV. *a*. The fix fore legs, Fig. I. *d*, move upwards in like manner, and feparate themfelves from each other, Fig. IV. *b*. Soon after the black horny bone of the fkull becomes fplit into three diftinct parts, by the fwelling of the trunk, horns, and the other parts lodged there, that lie under it. Of thefe three parts of the fkull, one is in the middle, *c*, and the other two, *d e*, are on the right and the left. This being accomplifhed, the firft obfervable change is the breaking out of the forks, or furcillæ, from under the fkin that covered them, *f f*.

As the Caterpillar ftill continues to move its body, the four pair of legs in the middle of it, Fig. V. *a a*, are by degrees thruft quite up to the tail, with the reft of the fkin; and the fame thing happens to the two pair of the fix legs of the firft feries, *b*. By this means the forks, *c*, become ftill more vifible, and the trunk, horns, and wings, begin to fhew their form. Laftly, the three pieces of the fkull, *d*, into which it burft, are found to be drawn up higher over the body.

The fkins being at length entirely depofited, all the parts, now mentioned, appear very plainly expanded over the body, Fig. VI. *a*, which, by this means, acquires a form altogether different from that which it before had. The wings, horns, trunk, and forks, which before were folded up and hid under the fkull, and the horny fubftance of the legs, are now difplayed; and the rings of the abdomen are alfo gathered up clofer to one another. The Caterpillar is now dignified with the name Aurelia, remaining all this time fixed to the web, *b*, by its claws. But as this cannot be fo well made to appear by a figure no bigger than the infect itfelf, I fhall give a drawing of thefe parts as magnified by the microfcope.

In the firft place appear the furcillæ, or forks, Tab. XXXV. Fig. VII. *a a*; then the middle part of the head, placed under the fkull, *b*: the root of the trunk, *c c*. The probofcis, or trunk itfelf, divided into two filaments, *d d*, and ftretched lengthways upon the body, *e*. Under the trunk lie the firft pair of legs, *f f*, whofe articulations are placed a little lower. Next to thefe are placed the fecond pair of legs, *g g*, which are ftretched out to a greater length, and thefe fhew their articulations at the extremities. Near thefe are placed the little horns, *h h*, whofe articulations alfo are very confpicuous. It appears that they are very thick near their points, *i i*, and on the forepart they bend themfelves back under the eyes, *k k*; but this circumftance appears better in the third figure, under the letters *a a*. The wings are ftretched along the fides, in the fame manner with the parts already mentioned, *l l l l*, and fhew very plainly the little ribs or nerves that go to form them, *m m*. The rings of the abdomen appear drawn toward one another, *n n*, with fome little prickles ftripped off their fkin, which look like fo many little prominent nipples, or papillæ. This beft appears by infpecting the left fide of the figure, where fome of thefe prickles are reprefented growing upon the infect's back, *o o*. Above thefe prickles there appear four breathing-holes, or puncta refpiratoria. Laftly, the tail, *p*, is very confpicuous, as well as the claws, *q*, that grow to it; and by means of thefe the Chryfalis hangs to its web. The hind legs are not to be found in this figure, becaufe they lie hid under the other parts which it was drawn to exhibit. The fame muft be underftood of the under pair of wings.

On turning the infect, thus changed and ftripped of its fkin, Fig. VIII. *a*, on its belly, it appears of a very extraordinary figure, the furface of it looking exactly as if covered with prickles and nipples; which is owing to this, that the fharp-pointed hairs of the Caterpillar have caft a fkin, as well as the other parts. A perfon, unacquainted with this branch of natural hiftory, might, by giving in this place a little loofe to his imagination, reprefent to himfelf the nofe, eyes, and other parts of the human face, as fome authors have already very ignorantly done; nay, they have given drawings of their idle conceits.

Ignorance is fruitful in falfe opinions, and is ufually accompanied with fo much felf-fufficiency, as makes it in a manner impoffible to overcome its prejudices; whereas thofe who have a tolerable fhare of knowledge, are in the readieft way to difcover their miftakes.

The Caterpillar, ftripped of its fkin, in the manner now related, is of a green colour, efpecially in thofe parts which are diftended by an extraordinary afflux of the blood. But after ten or twelve hours paffed without its fkin, it turns to the moft refplendent and beautiful gold colour. This is the reafon of its being called, in this condition, an Aurelia or Chryfalis. And as it is found fo common by every pathway, fticking to nettles, and fhining like polifhed gold, faftened to the leaves of the Pervinca, or periwinkle-plant, authors have, from this circumftance, taken occafion to give the name of Aurelia to all Caterpillars, changed after the fame manner in point of fhape, tho' the greateft part of them do not in the leaft partake of this rich colour, and the reft have nothing of it more than a few fpots.

It now remains that I fhould fhew, in a few words, in what manner all the laft enumerated

parts

parts are extended, and difpofed over the infect's body, in the orderly manner in which I have exhibited them. All this will become very intelligible to thofe, who will call to mind what I already faid, viz. that the extremities of the four wings, with the two hinder pairs of legs of the firft feries, are enclofed in one and the fame fkin; that the horns are folded up in membranes full of ligaments; and that the trunk is in the fame manner firmly faftened on the forepart of the fkull. This being the cafe, it is impoffible but that, on the pieces of the broken fkull, the withered legs, and the other fkins, rolling up towards the tail, all the new limbs, here mentioned, muft difplay and arrange themfelves in the moft beautiful manner, and by the jufteft and moft orderly evolutions; for the membranes I have named, that are fo full of ligaments, act the part of fo many ropes and pullies to extend thefe new parts, in proportion as the old are thruft over them. Now, if this change was to happen in fome creature of a larger fize, one, for example, equal to a Sheep or a Calf, is there any one fo infenfible, as that he would not be ftruck with the deepeft aftonifhment at the fight and contemplation of fuch wonders of the Divine Power? Certainly, God reveals himfelf as much and more in thofe myfterious and delicate operations, which the microfcope alone can difcover. Thus then, we at length fee evidently in what the change of the Caterpillar into a Chryfalis confifts, and what that Chryfalis or Aurelia, or the Caterpillar which has caft its fkin, really is; though the great Harvey moft prepofteroufly confidered it as an egg, and, enthralled by vulgar prejudices, ferioufly affirmed the fucceeding Butterfly to be generated by a metamorphofis, which, after all, he could neither explain or comprehend.

When the little creature has hung in the open air for fome hours, its external skin hardens by the power of that element; at the fame time that the enclofed limbs are, in a manner, fluid like water, on account of their great delicacy and tendernefs; fo that it has no power to move its wings or legs, till the fuperfluous humidity, that clogs them, is evaporated: then burfting its prifon, it appears in the fhape of a Butterfly; as fhall be prefently explained *.

The anatomy of the Chryfalis, two days after it has caft its fkin.

THE eyes were yet fo tender and delicate, that they diffolved with handling. The forks likewife were very moift; but, notwithftanding this, the articulations were very confpicuous; though, for the greateft part, they appeared like membranes, juft beginning to harden. The legs were in the fame condition with the forks; but, on account of the pulmonary tubes which appeared through their furface, they looked fomewhat more firm. The fame thing may be faid alfo of the horns. The wings within were quite colourlefs, and like a jelly; fhewing, through their tranfparent fubftance, pulmonary tubes, compofed, as it were, of mother of pearl.

As to the internal parts, the change in them is much more fenfible. The ftomach is confiderably fhortened, whilft the gullet is grown twice as long as it was in the Caterpillar, and runs in the form of a flender tube through the thorax into the abdomen. In the hinder part, the ftomach is reduced to a flender gut, and becomes fo very tender, that it breaks with the leaft touch: within this is found a fluid matter, of a deep red colour, inclining to purple, but not very thin. Under this there appears a kind of chalky fediment, of a fomewhat paler colour. The fix cœca, or clofed guts, that before joined the ftomach, are now wafted away, and no longer to be feen.

The heart and the fpinal marrow are become much fhorter; and this is all the confiderable alteration that appears in thefe parts. The particles, which I once miftook for the Caterpillar's filk-bags, are now become more flender, but more compact. The mufcles of the thorax, and thofe which are to move the legs and wings, have not the leaft ftrength or firmnefs, fo that on difturbing them, they immediately fell to pieces. The fat is grown yellower, thicker, and more friable, fo as to crumble with the lighteft touch. The pulmonary tubes are become fmaller, and they are carried in the moft elegant manner through the legs, wings, and other parts. There is a purple nodule, or knot, in fhape nearly round, fticking to the lower rings of the body. I could not now difcover the kidney-like particles, though I fearched for them carefully in three diftinct Aureliæ: but I have obferved in Caterpillars of another kind, that thefe particles at length unfold themfelves, and then feem to form fome other parts, which adminifter to the fpermatick organs.

* The repeated experiments of fucceeding naturalifts have, in every inftance, confirmed the doctrine of this author on the prefent fubject. The indefatigable Reaumer proved the truth of this evaporation of the abundant moifture from the Chryfalis, by different experiments. He enclofed the Chryfalis in a glafs tube, and he found the evaporated water collected in drops at the bottom of the tube: he covered the Chryfalis with varnifh; and this making the evaporation more difficult and flow, the Butterfly was two months longer than its natural time in coming out of the cafe. The fame author found alfo, that laying the Chryfalis in a warm room, haftened the difclofure of the infect; and keeping it in an ice-houfe, in the fame manner, delayed it. Warmth acts, in this cafe, in a double capacity, invigorating the animal, and evaporating the moifture.

The

The anatomy of a Chryfalis, fix or eight days after it has caft its fkin.

THE external limbs, and other parts, as the trunk, horns, legs, and wings, are by this time grown fomewhat more dry and firm, though ftill they are of a white colour, which is changing by degrees to gray. The alteration in the internal parts is now much more confiderable. The ftomach, which before might be confidered as forming feveral diftinct parts, is now fo wrinkled up as to be all of a piece, except that here and there appear fome globular fwellings above the furface. Thefe prominences are very obfervable on the forepart; but not fo diftinctly to be feen, by a great deal, where the clofed inteftines took their rife in the Caterpillar, about the hinder region of the ftomach. The moifture contained in this part is changed to a deeper purple. The mufcles of the thorax are become more confpicuous, diftinct, firm and folid; and the fat is ftill more and more contracted into a fimple mafs. I could now plainly perceive, that the purple nodule, or knot, was nothing more than a dilatation of the rectum, or ftraight gut, changed to this form. The rudiments of the genitals are by this time very vifible, and have begun to acquire firmnefs and ftrength.

The anatomy of a Chryfalis of twelve or thirteen days.

THE trunk, at this time, has acquired a confiderable folidity. The horns fhew their little fcaly feathers; and the legs, in like manner, very plainly exhibit their ftiff hairs, refembling briftles: but the fcaly little feathers are far from being fo confpicuous. The legs are alfo now of an obfcure gray colour, efpecially about the joints neareft the thorax. The hairs and little feathers of the wings are likewife very difcernible; but, as yet, they are very moift, and are laid fo clofe one upon the other, that it requires fome induftry to get a fight of them. They refemble, in fome meafure, the hairs of a Cat; in which, after the fkin has lain in the water for fome days, they are faftened together by the moifture they imbibe. The wings now will admit of being extended, and fhew, if they be torn, their pulmonary tubes, and other veffels. Their colour is an afhy gray, but obfcured by a dusky tinge. All the parts I have mentioned are quite complete, and perfect, in a Chryfalis of fixteen or feventeen days old. By repeating this diffection every day, we may, no doubt, obferve the moft extraordinary tranfitions, that can be imagined, from one colour to another; for, from a pale and whitifh or faint gray, thefe parts change to a dark colour, a deep brown, an elegant red, a yellow, a sky-blue, a bright white, and many other tincts; and this in fo furprifing a manner, that it is almoft impoffible to defcribe it: God, the author of all miracles, producing thefe alterations, in the nature of things, by rules which, at the fame time that they are moft firmly eftablifhed, infinitely furpafs the ftrongeft efforts our imagination can make to comprehend them.

The anatomy of a Chryfalis, of this fpecies, of fixteen or feventeen days old; at which time it is very near undergoing its laft change, in order to become a perfect Butterfly.

ON examining the Chryfalis at this period, we find, that its gold colour is become much paler; and it is fo tranfparent withal, as to let us perceive diftinctly through it all the colours of the upper pair of the future Butterfly's wings. If we ftrip off the skin, and other thin membranes that fheath the wings, thefe laft fometimes appear perfectly dry. But this principally happens in autumn, when thefe Chryfallides are generally fuffocated within their skins; the folar heat, at this feafon, being too weak to ftrengthen them fufficiently for the ftruggles which the burfting of their prifon requires, otherwife the wings always retain fome moifture. The forky particles, which I have before defcribed in the Chryfalis, now fhew themfelves hollow; and the eyes, which, like thofe of Bees, are furrounded with hair, appear under them very plainly. The trunk has acquired its due ftrength, firmnefs, and form, fo that it prefently curls and coils itfelf up, on taking off the cafe that covers it. Under the trunk are to be feen the true forks, between which the Butterfly hides that curious organ, as will appear in the defign I fhall give of that infect. The horns alfo are now perfect, and are covered with their little elegant fcales, which refemble feathers. The legs, with their little feathers, joints, and claws, are in the fame ftate of perfection; fo that, on ftripping off the coats and membranes in which they are bound up, they will begin to play, and move themfelves very fenfibly. Thofe legs, which, in the Chryfalis, lie moft expofed to the air, and which I have already reprefented in one of thefe defigns, as they appear upon the infect at that period, have in proportion a ftronger skin to defend them. The fame wife difpofition is alfo remarkable in the skin that defends the upper and lower pair of wings. When we examine the internal parts, it appears that the eyes are perfectly formed, being replete with thin pyramidal filaments, in the fame manner as thofe of the common Bee, as already mentioned. There are in the trunk two channels, which, uniting, form only one in the thorax, and conftitute the gullet, which ends at the ftomach. The mufcles of the thorax have acquired their due firmnefs, and confift of three kinds of fibres; fome running lengthways, others tranfverfely, and the third kind obliquely. Near the gullet appear the three little particles, which I took for the Caterpillar's filk-bags. They are at this time curled into one, and are inferted near the end of the gullet, to which they are united on each fide. A bladder full of wrinkles, and endued with a periftaltick motion, is now feen on the upper part of the ftomach; and it communicates with the gullet, by means of a flender tube. This bladder, the ftomach, and fome part of the gullet, are full of a deep purple moift fubftance; but the upper part of the gullet has nothing befide air in it. The ftomach, being gathered up into one mafs, in a furprifing manner, looks as if quite covered with tubercles. The back-part of it, like a little gut, is now become much more flender and fhorter, and is wrinkled withal, fo as to deferve the name only of an inteftine. The vafcula cœca, varicofa, or crocea, which were dropped from the ftomach, appear now in the fame place. Next were to be feen the inteftina craffa, or large guts, which, from being very fhort in the Caterpillar, are now become very long and flender, and appear as if they had been ftretched out to give them fuch an extraordinary length. They then dilate into a nodule, or knot, full of the purple matter already mentioned; and that dilatation is followed by another, greater than the firft; but its contents are the fame. The Chryfalis, on cafting its skin, difcharges this liquid from the anus; by which means the nodule, or knot, next to it comes to be fmaller than the other. This excrementitious fubftance, laid upon paper, looks like real blood. The ftomach, of the Aurelia I am defcribing, is much more firm, and of a much better confiftency, than that of the Aurelia of two days already fpoken of; infomuch that it may be now handled with the forceps, and drawn out of the body with the inteftines that are joined to it, without any damage or danger.

The heart and fpinal marrow are now quite contracted, and confiderably diminifhed. The fat is furprifingly wafted away, and wrinkled up by evaporation, fo as to refemble a bunch of yellow oblong grapes, which are fo firmly faftened to the pulmonary tubes, that the greateft care and patience is requifite to part them. There appeared no other alteration in the pulmonary tubes but this, that they were grown more membranaceous, and fhew more diftinctly their mufcles, and other parts, which had now acquired their proper degree of perfection. The kidney-like particles are now no longer to be feen: perhaps they have been expanded by a flow growth into the organs of generation, which now fhew themfelves very diftinctly; but are fo intimately united with the fat and pulmonary tubes, that it is almoft impoffible to feparate them, unbroken and entire. This makes it neceffary to attempt the diffection of the genital parts in the Butterfly itfelf: I therefore hope, that, when I fhall have proceeded fo far, I fhall be able to give a fatiffactory defcription of thefe parts, with figures to illuftrate the accounts; provided my health does not fail me, and I do not want proper fubjects to work upon. I fhall likewife defcribe at the fame time, and in the fame manner, the gullet, ftomach, and inteftines, with figures of them.

In what manner the Aurelia affumes the form of a Butterfly.

WHEN this, as I may juftly fay, furprifing alteration of the infect, by the growth, and removal of the limbs, and other parts, happens in the month of June or July; it requires only about eighteen days to perfect it in this fpecies: whereas late in autumn, it requires ten days more; fometimes indeed a great number of Caterpillars, by not beginning to change till the feafon is thus far advanced, perifh for want of ftrength to caft their fkins; fo that, on this occafion, thefe little creatures are liable to the common calamities of nature, and very often come to an untimely end.

Nothing is more remarkable about the time when the Aurelia begins to caft its fkin, than the perfection to which the wings, which have grown under it, are arrived. The colours that adorn them are chiefly black, red, and a fky-blue; and thefe, as well as the trunk, legs, and horns, may be very eafily difcerned through the fkin that covers them, even without the help of a microfcope, Tab. XXXV. Fig. IX.

On examining, with a microfcope, the Chryfalis at this period, the extremities of its legs are obferved to move very diftinctly: a circumftance which I have often remarked in the Aurelia of Silk-worms, with the greateft aftonifhment.

The colours of the under pair of wings cannot be feen, becaufe they are altogether covered by the upper pair; nor are the colours of the other parts, juft now mentioned, very difcernible, becaufe there is not fo great a variety of tincts in thofe parts. For though the colour of all Chryfallides appear through their fkins, at the time they are going to caft them off; neverthelefs, it is impoffible to tell exactly what thofe colours are, where there does not happen a confiderable diftinction between them and the ftain itfelf.

While

While the little creature remains in this condition, there is a violent agitation in its blood, and a motion in all its internal parts. The blood, in a hafty fermentation, is driven through the veffels from the heart into the wings, which are likewife fupplied with air from the lungs. The infect, befides, labours violently with its legs: and all thefe motions concurring with the growth of the wings, it is impoffible the tender fkin that covers it, fhould not at length give way; and this it accordingly does, by burfting into four diftinct and regular pieces.

Firft, That part of the fkin which covers the trunk, the two fore-pair of wings, the horns, and the furcillæ or forks *, falls off from thofe parts; but the feveral portions of it, in which they were feparately wrapped up, remain firmly united together, Fig. x. *a.* This is the firft time the legs appear without any covering, and they then help greatly to free the body, and the other parts that remain yet bound up. At the fame time, the fkin on the back flies open, and dividing itfelf into two regular portions, *b b*, difengages the back and the wings. Then there likewife happens another rupture in that portion of the fkin, which covered the rings of the back of the Aurelia, *c.* After this the Butterfly remains very quiet for fome time, with its wings pointed downwards, and its legs fixed in the fkin which it has juft caft off.

But it muft be obferved, that the wings, legs, horns, trunk, and other external parts of the Butterfly, do by no means rife from the body in the manner exhibited in the II Figure of the Table XXXV. where I have laid down all thofe parts, as they appear very diftinct and confpicuous in the Caterpillar itfelf. Many of thefe parts remain as has been already faid, firmly united to each other, the reafon of which is, that they are all moift and wet in the Caterpillar, at the time when it is about throwing off its fkin, and becoming a Chryfalis; and this moifture being of a clammy or glutinous nature, ferves, on its being dried by the air and heat of the weather, as a real glue, to unite the parts it lies between fo firmly together, that they never feparate for the future. Now, as the fkin, which lines all thefe parts, or covers them on the infide, is extremely delicate and tender, which it well may be, as it is not expofed to the air, it all breaks and flies off without any certain order; nor is any order neceffary upon the occafion. Hence it arifes, that fo many broken and ragged little membranes, almoft as thin as a cobweb, appear on the inner furface of the fkin that has been thrown off. One of thefe little films is to be feen between the conglutinated coats or fkins of the trunk, horns, and other parts, Tab. XXXV. Fig. x. *d.*

There likewife appear within the fkin certain white filaments, *e e.* Thefe are the caft coats of the pulmonary tubes; for now thefe tubes caft their fkins for the laft time. The greateft part of the eighteen pulmonary tubes, of which I have reprefented nine on one of the fides of the Caterpillar, in the fecond figure of the XXXIV. Table, remain in the Aurelia, which breathes by them, until by cafting this fkin it becomes a perfect Butterfly; and this is the reafon, why the pulmonary tubes are much more flender in the Butterfly, than they were either in the Caterpillar, or the Chryfalis: this circumftance alfo affords the Butterfly the means of taking more air into its body, and thereby renders it the better able to fly, to give a due motion to the contents of its inteftines, to fuck in the juices on which it lives, to void its excrements, and to perform many other operations neceffary in the animal oeconomy.

At the time when this change of skin happens, the wings expand fo rapidly, that the naked eye cannot trace their unfolding, from reaching fcarce half the length of the body, Tab. XXXV. Fig. XI. *a*, they acquire, O miracle of miracles, in the fhort fpace of about half a quarter of an hour, their full extent and bignefs, fo as to be each of them five times larger than they were before. Nor is it the wings alone that are thus increafed: all their fpots and colours heretofore fo minute, as to be fcarce difcernible, *b b*, are proportionably extended; fo that what but a few minutes ago, appeared but as a number of unmeaning confufed points, are now become diftinct and moft beautiful ornaments. All this may be beft conceived, by confulting the XII Figure, which reprefents the wings bigger than the body, and with all their colours, which are chiefly red and black. About the edges, however, here and there fome yellow, sky-blue, and white fpots, are feen moft elegantly combined, which exhibit to us, though faintly, and as it were by fhadows, the inexhauftible treafure of the Great Creator's treafures, his ftupenduous majefty, and his other incomprehenfible perfections; for though no adequate reprefentation can be given of the Supreme Being, he has thus been pleafed to fhew himfelf to us, diftinctly and confpicuoufly enough to engage our love, our adoration, and our gratitude.

This little creature is found alfo to have four legs, Fig. XI. *c c c c*, each armed with claws, and adorned with hairs, and a variety of colours. The two horns *dd*, lie juft above the eyes: near the fpace between the eyes, are to be feen the forks or furcæ; from between which the infect darts *e* out a double trunk, the ufe of which is to pump out the fweet juices from flowers into its body, fo that this organ may be confidered as its tongue. When this curious part is not at work, it lies fo clofely curled and coiled up between the forks, that it cannot be feen. This beautiful contrivance is reprefented in the XIIIth Figure,

* Thefe appendages to the trunks of Butterflies have been fuppofed by fome to affift in the procuring, difpofing, or forcing down the food: but the nature of the Butterflies food is a plain contradiction of that opinion; for it is only a liquid, and thin honey juice. Reaumer has therefore, with more juftice, alloted them the office of preferving the trunk from injuries, and fupporting it in its intended ufe. This is confirmed by the conftant obfervation, that thefe pieces or forks are always ftronger in proportion, as the trunk is more tender.

Figure, in which we likewife fee, that the Butterfly's wings entirely cover its legs. The firft pair of legs lie nearly under the thorax; but they are now fo altered, as not to deferve that name; for the Butterfly makes no ufe of them as legs, nor have they claws like the others: nature, indeed, feems to have intended them for fome other purpofe.

As the wings extend themfelves fo fuddenly, they accordingly appear at firft like pieces of wet paper, foft, and full of wrinkles, cavities, and fwellings, as I have reprefented them in Tab. XIII. Fig. IX. X. XI. But they are quite dry in half an hour, by which means all the inequalities in them entirely difappear, fo as to leave them perfectly fit for the creature's fervice. The Butterfly's tranfmutation being thus perfectly finifhed, it difcharges three or four pretty large drops of a bloody liquid, which are the laft remains of the fuperfluous moifture, the reft of which has been evaporated by the Aurelia during the heat of fummer, in the fpace of about ten days; for as the parts, which this moifture was intended to expand, no longer need any increafe, what remains of it is no other than an ufelefs encumbrance, and accordingly it is expelled from the body as an excrement.

Thus the Butterfly, in a little more than a quarter of an hour, acquires its full perfection. During the Caterpillar-ftate, it may be confidered as a newly conceived embryo. In that of an Aurelia, it reprefents a child as yet fhut up in the womb, but about to break the membranes in which it is bound up, in order to make its efcape. Laftly, the infect, when employed in extricating itfelf from its integuments, refembles the infant juft coming into the world. However, there is this confiderable difference between them, which well deferves attention. The Butterfly does not produce itfelf like our wretched offfpring, weak, tender, and in a manner but half perfected; but, almoft from its firft moment of appearance in this ftate, it is a complete creature of manly age, if I may be allowed the expreffion, and qualified in every refpect to avoid fuch things as are hurtful, and look out for thofe that tend to fecure its exiftence, for the fpace allotted by nature, and make it agreeable.

Whoever confiders thefe particulars attentively, muft obferve, in this poor infect, a great and indeed immenfe degree of perfection, which man, the greateft work of the creation, entirely wants. And this profpect fhould fill us, miferable mortals, with fentiments of the moft profound humility. We fee a little infignificant infect, diftinguifhed from its laft birth, with qualifications, ornaments, and perfections, which, during our ftay upon earth, however long it may be, we can never flatter ourfelves with the hopes of enjoying.

This creature, to fupport life, needs no other food but the dews of heaven, and thofe limpid diftilled juices, which it finds ready prepared for its ufe by the beneficent fun, and plentifully ftored up in every flower. No theatrical fcene can be imagined equal to the ornaments with which it is cloathed; and that its wings, and the rich colours that embellifh them, were beftowed upon it merely for the fake of ornament, appears from its being able to fly with but two, as well as with four wings. The skies are the Butterfly's proper habitation, and the air its element; whilft man, miferable in every refpect, is obliged to earn his bread with labour and cares: he comes into the world naked, and deftitute of all external ornaments, to demand attention; and, born in this wretched condition, he roves about without habitation or fhelter, expofed on the one hand to the heat of the fun, on the other, to the damps and exhalations of the earth, both enemies alike to his happinefs and exiftence.

Indeed, upon mature thought, we have no caufe to be furprifed at this difference. We are at prefent exiles from heaven, our proper home; ftripped of that beautiful cloathing which our firft parents poffeffed. But this is not the only creature, from whence we may draw ufeful inftructions. All other kinds of infects are generated in the fame manner. Not one of them grows the value of a fingle line, after the half hour that immediately fucceeds their extricating themfelves from their skins for the laft time. We admire with the greateft aftonifhment, how the bodies of the flying infects could be contained in the little skins and membranes, out of which they came to appear in this ftate; whereas the wonder confifts entirely in their expanding fo much, and acquiring fuch perfections in the firft few minutes that fucceed their enlargement.

How then can we avoid crying out, O God of miracles! how wonderful are all thy works! how beautiful are the ornaments! how well adapted the powers which thou haft fo profufely beftowed upon thy creatures! They are all, notwithftanding, fubject to decay and deftruction; and, with all their perfections, fcarce deferve to be confidered as fhadows of the Divine Nature. It is therefore, with the higheft reafon, that a certain writer has faid, That all nature is over-run, and covered with a kind of leprofy. This is her old garment, which fhe is one day to throw off, and its heavinefs alone is fufficient to weigh down our fenfes, and difturb our reafon, in fpite of all its efforts.

Goedaert defcribes the Caterpillar I have here been figuring, and the Butterfly arifing from it, in the XXI. experiment of the firft part of his natural metamorphofes; but he forgot in his figure the Caterpillar's prickles, inftead of which, he gives it nothing but fimple hairs. He has, befides, been guilty of another miftake, in beftowing breathing-holes on every one of the Caterpillar's rings. Mouffet alfo has favoured us with figures of the Caterpillar, and the Butterfly, and has defcribed the Butterfly according to its colours. But Goedaert's drawing of it, deferves the preference by many degrees.

The beauties of the Butterfly now before us, Tab. XXXV. Fig. XII. is but of a middle rank, if compared with that of many others. Its head is covered with little black hairy and fcaly feathers; the eyes, which take up the greateft part of the head, are thickly guarded alfo with hairs refembling briftles; and they confift of a fubftance ſtance which looks like gold, on account of the brightneſs of the uvea, which is ſeen through. The thorax and abdomen, are black; but they are covered with hairs of a golden yellow. The legs and horns conſiſt of a black, bony, or horny ſubſtance, and are adorned alſo with ſcales and hairs of a gold colour. The wings look as if they had been ſlightly waſhed over with a deep red blood-coloured paint; and they have, beſides, four great and four ſmall ſpots of different forms. Near the thorax, the upper wings appear moſt elegantly ſprinkled and waved with glittering gold; and the lower wings near the belly, are covered with hair of a gold colour. The ſpaces between the ſpots of the upper wings inclines to yellow; but near the third pair of thoſe ſpots which lie towards the edges, are two other marks of a ſnowy white. The borders of the wings are elegantly indented, and ſet off with four principal colours, a black, a sky-blue, a peach-bloſſom colour, and a yellowiſh red. The sky-blue, by bending its courſe upon the black, which ſerves as a ground to the other colours, forms a beautiful creſcent; whilſt the other colours, making ſo many circles, ſeparated by the black ground, heighten the elegance of the diſpoſition in a very delicate manner.

CHAP. III.

Containing a deſcription of the internal parts of the male and female Butterfly, deſcribed in the preceding chapters.

HAVING deſcribed the external and internal parts of the Caterpillar, and of the Chryſalis, and alſo ſome of the Butterfly's external ornaments; my next task is to deſcribe its internal ſtructure; though I cannot ſay I have ſucceeded perfectly to my wiſhes, in examining and inveſtigating them one by one, as I propoſed to myſelf. For, as I did not begin to diſſect the inſect in this ſtate, till towards the end of Autumn, and had ſuch only to diſſect as had been changed to Butterflies within doors, and under my inſpection, and had not acquired their full perfection; for this kind of Butterfly outlives the year in which it makes its firſt appearance I could not therefore obſerve all its parts ſo accurately as I wiſhed: beſides, there was no bright weather during the time my examination laſted; but the air was continually darkened with rain and clouds. However, ſome things in my obſervations appeared worthy of notice, which I ſhall now briefly relate.

On opening the Butterfly's back, there immediately appear in the thorax, ſome little wrinkled veſſels, Tab. XXXVI. Fig. I. *a a*, which lie near the gullet, and have their inſertions in the forepart of the body. I take theſe little veſſels to be the ſame with thoſe already repreſented in the vth Figure of Table XXXIV. Their beginning is a ſlender little channel, *b*, which divides into two fine tubes; and theſe tubes again dilating themſelves, *c*, terminate at laſt about the beginning of the ſtomach, *d*; and they are ſo firmly united and faſtened to it, by means of the fat and muſcles, that I have not yet by any means been able to looſen them from that part, or to trace them higher. What greatly increaſes the difficulty is, that the beginning of the ſtomach itſelf, is here very ſtrongly connected. What the office of thoſe veſſels is, and whether they may not be the ſalival ducts, I cannot take upon me to determine; for I know not how they terminate in front, or whether or no they have a communication with the trunk, *e e*.

Amongſt the curled veſſels I have been treating of, appears the gullet, *f*, which dividing in the upper part, near the root of the trunk, into two little tubes, conveys to the ſtomach the juices ſucked in by that organ. From the lower part of the gullet near the ſtomach, there iſſues a ſhort and ſmall channel, *g*, which ends in a little ſlender bag, *h*. This bag is no other than an air-bladder, into which the air ruſhes, whilſt the inſects food is making its way to the ſtomach. This bladder is endued with a very conſiderable periſtaltick motion: it is almoſt always found in the Butterfly's back, placed over the ſtomach. In the Chryſalis, I found it full of a deep red liquid, as has been already obſerved.

The ſtomach itſelf, *i i*, is ſtrangely altered in regard to ſhape, from what it was in the Caterpillar, as before repreſented in the ivth Figure of Tab. XXXVI. It is now entirely ſwoln and tuberous, and it reſembles an inflated large gut; ſo that, on account of its many folds, hollows, and wrinkles, it exhibits a very pleaſing ſight in the hinder part. It ſo much reſembles one of the ſmaller inteſtines, *k*, full of moſt delicate folds, that I cannot take upon me to determine whether or not it ought to be conſidered as ſuch, rather than as a portion of the ſtomach. Under the pylorus, appear ſix inteſtina cœca, or vaſa varicoſa, *l l l l*, which are much more ſlender in this ſtate, than they were in the Caterpillar, and of a perfectly different form. They are likewiſe ſeparated here from the ſtomach, to which, in the Caterpillar, they always cloſely adhered by means of the pulmonary tubes. I have not as yet been able to find out where and how they terminate in the Butterfly, ſo that I ſhall only repreſent them here as they appeared to me on this diſſection. Under theſe lie the ſmaller inteſtines, *m m*, which are tranſparent and full of a globular ſubſtance. A little lower the gut widens conſiderably, ſo as to form the cloaca, *n*; then it contracts again, to dilate a ſecond time into a leſſer ſinus, *o*, in which it terminates. Next follows the ſtraight gut, *p*, terminating in a ring, of a ſubſtance between bone and horn, which forms the anus, *q*, is covered with hair, and drawn up within the abdomen. At the ſides of the anus appear its proper mufcles, *r r*: their tendons are black, and of a fubftance like that of the anus itfelf. The two dilatations of the inteftines, which I have juft now taken notice of, fupply the place of a colon, which appears only in the Caterpillar; for in the Butterfly it is fo transformed, as defervedly to be confidered as a different part. Certainly the furprifing and incomprehenfible changes of parts which we here obferve, fhould engage our utmoft attention, though for many reafons, yet for none fo much as for this, that they moft evidently demonftrate to the whole univerfe, the excellency of the Great Creator. The contemplation of thefe wonders has often led me to confider, whether the entrails of Nebuchadnezzar, when deprived of his reafon, and armed with talons, like a bird of prey, covered with hair, fuch as is found upon beafts, and condemned to eat grafs in common with the cattle of the field, did not fuffer a change in his internal parts, correfpondent to that which appeared in his external form; and fuch a change as might fuit them to digeft the food, with which his life was to be fupported, in the courfe of this his moft examplary penance. At leaft there appears an occafional alteration of this kind in the entrails of thefe infects; for, as long as they continue under the form of Caterpillars, and live upon a grofs and earthy food, their entrails are alfo grofs and earthy; whereas thefe creatures, affuming a more delicate form, and beginning to fubfift on a more pure fubftance, the organs by which fuch fubftance is to be taken in, digefted, and diftributed to the feveral parts of the body, become likewife more delicate, and that indeed to fuch a degree, that the alteration would never be credited, if the eye did not trace its gradations from one day to another.

There is no part of the Butterfly that deferves our admiration more than the trunk *. I have but rudely delineated this organ, becaufe I propofed making many other figures of it, confiderably bigger than the life, which, after all my pains, I have not been able yet to perform, on account of the badnefs of the weather, and the feafon's being now fo confiderably advanced. That extremity of it, with which the Butterfly fucks in its food, is particularly curious in its conftruction: it confifts of a double tube, divided, as it appears, into many articulations. This conftruction fuits it to a great variety of motions, and in particular, makes it eafy to ftretch out, and curl up again. It appears, that when the Butterfly fips up the honey or liquid fugar upon which it lives, a portion of air mixes with and accompanies this through the trunk to the ftomach. This may be feen by faftening the Butterfly by its wings, with a very fine pair of iron pincers, and uncurling the trunk with a very fine needle, fo as to bring the tip of it to bear upon a blade of grafs dipped in fugar water; for the Butterfly immediately fucks the nourifhment that is thus offered; and, with the affiftance of a microfcope, both that and the air that goes along with it may be traced in their courfe into the body: and this is a very entertaining fight. Indeed Butterflies may be kept alive in this manner many days together: they will take fo well to this way of feeding, that at laft they will dart out of themfelves, without any compulfion, their trunk into the moiftened fugar, or honey water, thus offered them. Hence we may guefs how fine and delicate the mufcles, veins, arteries, and nerves muft be, by which this little organ is fupported and governed. The very extremity of it is of a moft amazing ftructure. As for my part, I muft ingenuoufly own, that neither my eyes, my hands, or my head, are equal to the task of infpecting, handling, or perfectly defcribing it: but even this weaknefs is an ufeful leffon, fince I learn by it, that all our boafted knowledge and perfection in this life, is in the main but ignorance and mifery. Let it therefore fuffice, that the things we fee, are capable of conducting us, as it were, by the hand, to the knowledge of a much fublimer being; and let this confideration engage us, to adore the Divine Majefty, according to the perfect rules he himfelf has been gracioufly pleafed to prefcribe to us, and to perform, with due reverence, the penance enjoined us for tranfgreffing his commands. This is the one thing neceffary; all elfe is vanity of vanities, and altogether unworthy of our attention.

The genital organs of the male Butterfly.

ON diffecting a male Butterfly of this fpecies, four days after its laft change, the genitals appear perfect in every refpect. The penis, Tab. XXXVI. Fig. II. *a*, placed near the extreme rings of the body, has on each fide two horny little bones, *b b*, of a pale brown colour, which cover it behind and in the middle. Thefe little particles have an articulation, with a border, *c*, of the fame fubftance, which furrounds the penis like a belt There is near the two little horny parts, already taken notice of, another that is hooked, *d d*, and behind, is divided in two; by the parts of the penis, *e*. On raifing the two firft little horny bones, there appear two crooked little claws, whofe bufinefs it is to grapple, and firmly hold, during the act of copulation,

* The trunk of the Butterfly is indeed an organ of moft wonderful ftructure. It ftands in the part of the head where a nofe might be expected, but it really is of the nature of a mouth; for all the food goes through it. The fubftance of the trunk is horny: the creature may be faid to unroll it, by fqueezing the head; or it may be drawn out with a pin. After this, if any violence be ufed to the creature, the trunk will crack lengthways in the middle, and the flit will run prefently through its whole length, and divide it into two. Bonani hence fuppofed the trunk was really double in the Butterfly, or originally compofed of two. Riget thought he had fhewn, from unqueftionable experiment, that the trunk of this infect was fingle, and that this fplitting was the effect of the violence offered to it, and its own tender ftructure. He had his followers, till Reaumer verified the firft doctrine of Bonani by more accurate trials; and eftablifhed the true ftructure of this part, which is, that it is compofed of two delicate tubes, laid parallel by one another.

pulation, the loweſt abdominal rings of the female Butterfly. This action is particularly obſervable in the common white Butterflies; for the female of this ſpecies very often flies about with the male faſtened to her, his claws or hooks in this part graſping her genital parts cloſe to him, his head hanging down, and his wings quite motionleſs. The muſcles of theſe parts of the penis appear between, and have their inſertions in, the little horny parts already taken notice of. On the inſide, near the two little grappling claws, there appear ſome other parts belonging to the penis; but I could not examine them with the due exactneſs. The penis conſiſts partly of a bony and partly of a nervous ſubſtance. The former reſembles, in figure, the little bone we find in the penis of Dogs; and has at its extremity an opening, thro' which the ſoft and nervous portion of the penis is erected at the time of copulation. The root of the penis is likewiſe of a nervous ſubſtance, *f*, but more compact than that portion with which the erection is performed. Next we obſerve the baſe of the penis, *gg*, containing in one part a white ſperm, and in another part a thick fluid, divided into very minute granules; which, on letting it out by wounding the penis, ſhines like a white or ſilver ſand, *i*. I leave to others to inquire what this laſt ſubſtance may be. The penis appears, in this part, very elegantly folded and curled up into two branches, *k*, which afterwards form four others, whoſe origins are all very firm and ſtrong. I am not diſpoſed to affirm any thing as a certainty, concerning the nature of theſe laſt portions. The two ſlendereſt branches, which appear moſt cloſely twiſted one with another *ll*, look like ſeminal veſicles; for they contain a white ſpermatick liquid, conſiſting of very minute grains, connected together by a membrane. The two other branches may paſs for the vaſa deferentia of the inſect, *m m*; and the nodule, or knot, *n*, in which thoſe branches terminate, for the teſticle; ſo as to make it probable, that the Butterfly has only one teſticle. But theſe are only conjectures on a ſubject, concerning which I dare not advance any thing as a certainty.

This globular portion, which I call the inſect's teſticle, is of a pale gray, with a tinge of a purpliſh colour, and it is ſurrounded by two coats. The outer coat is very fine, and is united with a great many pulmonary tubes. The inner coat is much thicker, and yields, on diſſection, a ſoft, clammy, and glutinous ſubſtance, no way fluid. Through this there run a great number of pulmonary tubes, of a bright ſilvery whiteneſs, variegated with ſome purple ſtreaks. Perhaps repeated diſſections may enable us to determine, whether or not this portion is to be really conſidered as the Butterfly's teſticle. Theſe parts are ſo firmly connected on every ſide, by means of the fat, and of the numerous pulmonary tubes, as to make it a very difficult taſk to diſplay them. The rectum, or ſtraight gut, opens under thoſe particles belonging to the penis, which conſiſt of a ſubſtance between bone and horn, already taken notice of. The pulmonary veſicle, that is ſituated forwards near the ſtomach, appeared to me full of air. The ſtomach itſelf looks like a bunch of grapes; and cloſe to it lie the cœca, or cloſed guts. The ſmall gut is conſiderably longer than the ſtomach, and ends in ſome dilated parts.

The preceding obſervations I made the ſixth of September on a Butterfly, which appeared, for the firſt time, as ſuch that very day, and had been changed from a Caterpillar into an Aurelia the 17th of the preceding Auguſt; ſo that its change, from a Caterpillar to a Butterfly, took up nineteen days.

The anatomy of the ovary of this ſpecies.

A Few days after, I opened a female Butterfly, reſembling ſo exactly, in its internal appearance, the male before diſſected, that at firſt I imagined I had again got a male under my hands, till the thickneſs of the body indicated the contrary; and ſoon after the diſcovery of the oviducts confirmed me in my laſt opinion of the inſect's ſex. There were, as yet, no eggs in theſe ducts, ſo that they appeared very like the genitals of the male; and, indeed, it was ſome time before I could be ſure that they belonged to a female. Many of the inſects, whoſe date of life is of ſome length, have no eggs in the beginning, or very imperfect ones. I have indeed obſerved, that almoſt all inſects die very ſoon after they have prepared their ſperm; unleſs when their ſperm, though viſibly formed, has not acquired its full growth; or when the inſects are to ſurvive the winter, in order to lay their eggs the enſuing ſpring; as is the caſe of the Butterflies which I am now deſcribing. Nor does it appear probable to me, that either the eggs of inſects, or the inſects themſelves, in the Caterpillar or Aurelia-ſtate, can endure that rigorous ſeaſon; for which reaſon the little creature, now perfect in the Butterfly-form, is doomed to the hardſhips of this ſevere trial. Hence it is, that at the approach of winter they take refuge in the hollows of trees, in ſtore-houſes, and ſummer-houſes in gardens, where their blood is condenſed by the ſucceeding colds, like olive-oil at the ſame ſeaſon, and becomes, in a manner, quite caked; ſo that they neither move nor eat till the returning warmth enlivens them. This I have often obſerved. They even diſcharge no excrements all the time. I have made many curious experiments upon Butterflies in this condition; but it would take up too much room to give an account of them in this place.

There are ſix oviducts, Tab. XXXVI. Fig. III. *a a a a a*, in the female Butterfly now under our inſpection, and theſe all terminate in one common paſſage, *bb*; ſo that, in this part, the

the oviducts resembles a single trunk, which is a hollow channel, ordained to receive the eggs in their descent from the others. On each side of the channel are five little tubes, *c c c c c*, with their extremities closed. These open into the passage, and discharge upon the eggs, in their course, a glutinous matter, which makes them stick to the nettles upon which they are dropped. The construction of these little receptacles of the viscous matter is extremely elegant: they consist of various dilated tubercles, with lateral ramifications, which are likewise dilated again, and serve, in my opinion, to secrete and elaborate the glutinous substance here spoken of. On the other side of these ducts there arises, from the ovary, a much more slender tube, *d*, terminating in an oblong bag, *e*. This contains, as it were, two different substances. The contents of the upper part, *f*, is yellowish; and, on endeavouring to extract it, the membrane, constituting the bag, shews itself to have some strength. As for the yellowish substance, sticking to the inside, it looks very like the fat of the Butterfly. The substance, enclosed in the lower portion of this bag, resembles a limpid humour, and appears as such through the transparent *g* membrane that forms the bag. The other end of the little tube, just taken notice of, opens at its extremity into the external parts of the ovary, or the vagina, *h*, which has a little elegant horny bone, of a bright red colour, that extends from the womb to a considerable height within the vagina, and has an opening, which I have marked with the letter *i*.

All these parts of the ovary adhere so firmly together, by means of the pulmonary tubes, Fig. IV. *a a*, and fat, *b b b*, that I have often lost my desire of endeavouring to display them, together with the hopes of being able to effect it: but patience, in the end, got the better of those obstacles.

These little creatures are very readily killed, by dipping them into spirit of wine. They likewise die in a very short time, on putting them into a box containing Brazil-snuff. I have observed also, that other insects are subject to the same fate; though, at first, it was by meer chance that I discovered it.

I have thus briefly recounted what I have been able to discover, concerning this little creature, in the space of a few weeks. But if I had been master of more leisure, and the autumn had not come upon me so soon in the operations, I should be disposed to mention, more at large, many other things worthy of admiration, which fell in my way; though I have not yet examined them with the accuracy they merit. Such, for example, as the true manner of the Butterfly's wings acquiring their size with such an amazing celerity; as well as the art by which the tubercles, bladders, and pustules may be imprinted on the wings; how the Caterpillar may be delayed and hastened in the course of its change; by what means all the colours, which appear through the skin of the Aurelia, may, in that short time of their appearance, be so firmly fixed as never afterwards to grow and spread. I had besides proposed representing, a great deal larger than life, all the spots, lines, and colours of this little creature; as likewise its hairs, feathers or scales, and pulmonary tubes, the articulations of its legs, and many other mysterious works of nature observable in it; all which I have elsewhere promised that I would some time or another describe.

The End of the wonderful History of the Diurnal or Day Butterfly.

An Animal in an Animal; or the Butterfly hidden in the Caterpillar; which is a third particular example, serving as an additional illustration to the second method of the third order or class of natural transmutations.

Tab. XXXVII.

THOUGH, by the particular experiments before advanced, it has been justly shewn what changes of the third order are peculiar to the first and second species or method of transformation; I shall here, by way of further proof describe and figure the manner in which I can find a Butterfly enclosed and hidden in a Caterpillar, and perfectly contained within its skin. This I demonstrated, in 1688, to those eminent persons Magalloti and Thevenot.

But before I proceed to this, it is necessary to observe, that the Caterpillar, Chrysalis, and diurnal Butterfly, which I exhibit in these figures, are the same species with those which the diligent Goedaert has figured Tab. XI. Part 1. And the often celebrated and learned Mr. Ray, in his treatise on the plants owi ng about Cambridge, Page 134, has particularly described a Caterpillar of this kind.

Tab. XXXVII. N°. 1. I exhibit the egg of the said Butterfly in its natural size. This egg, as I have described in general before, is really the Caterpillar itself, enclosed in this condition, and invested with a membranaceous cover, or integument. Indeed, this Caterpillar lies hid in its membrane, in the very same manner as the Nymph or Chrysalis does in its integuments. I have before treated this matter at large; and the whole will be again more accurately debated under the account of the fourth order: therefore I shall not here exhibit a more ample explanation thereof. I am now only to demonstrate clearly, that the Caterpillar is the Butterfly itself, and that this Butterfly lies enclosed in the skin of that Caterpillar, in the same manner as the Caterpillar does in the cover or skin

ſkin of its egg. And all theſe things will appear plainly from what ſhall be ſaid immediately.

FIG. I.

The egg of that Butterfly, which is repreſented in N°. VI. is expreſſed in this firſt enlarged figure; in the exact manner wherein it appeared under the microſcope. It is obſerved hence to be, as it were, conſtructed of fifteen ſmall ribs; each of which manifeſtly throws a ſhade on the adjoining membrane, ſituated between thoſe ribs: and hence it is, that, to a perſon looking at the egg, it appears, about the ſhady parts, to be divided by as many other ſmaller ribs. Theſe ribs, and the membrane of the egg between them, are alſo divided croſſwiſe by regular grooves or channels. It may be alſo ſeen how all theſe ribs concur, as it were, in a center toward the ſmaller extremity of the egg, and extend themſelves beyond its ſurface. This egg, when arrived at its full increaſe, is of a yellowiſh colour; but it is white, when it is freſh in the oviduct. That is, I obſerve that thoſe eggs in the oviduct, which are firſt to iſſue forth, are perfect; but thoſe that poſſeſs an higher place are ſmaller, though they are of the ſame figure with the former. Thoſe that are ſituated higheſt in the oviducts, appear ſquare; and ſuch as lie yet in the extremities of the oviducts are ſo wonderfully ſmall, that at length they become entirely inviſible. The ſame is likewiſe obſerved in the eggs of another Butterfly of this kind, but ſmaller in the body and wings. I ſaw thoſe laying their eggs in the month of May, and faſtening them to cabbage-leaves, in ſuch a ſituation as I have herein delineated the egg of this larger Butterfly; that is, ſo that the ribs run upwards, but the globular baſis poſſeſſes the lower parts: the ſame thing holds with reſpect to theſe eggs. As the Butterflies, iſſuing from theſe, are found all the year, it is probable they lay their eggs at various times. This, however, ſeems to be done chiefly in Autumn, when we obſerve their Caterpillars in much greater numbers than at any other ſeaſon.

N°. II. I exhibit the caſt and forſaken coat of what is called the egg, which a little before, I have obſerved, was the real Inſect or Caterpillar of the Butterfly; ſince this Caterpillar, like the Chryſalis, is found encloſed in its ſkin, even within the egg.

No. III. The Caterpillar of the Butterfly, or the Butterfly lying concealed in the form of a Caterpillar, is here repreſented as it appears at the full term of its growth. In order to demonſtrate clearly and diſtinctly, that this Caterpillar is the real Butterfly, and the latter again is the Caterpillar itſelf; I ſhall firſt deſcribe the external figure of that Caterpillar, which conceals the Butterfly within its ſkin. As the celebrated and learned Mr. Ray has, before me, very clearly and perſpicuouſly performed this taſk, I ſhall therefore make uſe of his words, deſcribing the Caterpillar in this manner. "If we conſider the bigneſs of the Caterpillar that feeds on cabbage, it is of a "middle ſize, between the largeſt and ſmalleſt "kinds; and is covered with whitiſh, thin, "ſhort hairs, no where cluſtered together or "entangled. The colour of the body is va-"riegated, and compoſed of black, yellow, "and blue; whereof the yellow deſcribes "three lines as long as the body, that is, one "in the middle of the back, and the two "others on the ſides oppoſite to each other. "Between theſe lie the black and blue: the "former painted in ſpots, the latter more "diffuſed. Theſe black ſpots alſo are protu-"berant above the reſt of the body; and out "of each of their centers, where they appear "blacker than elſewhere, they emit the hairs "before mentioned. The head likewiſe has "the three aforeſaid colours mixed together, "and it is covered with the like hairs. The "legs, being ſixteen in number, are orderly "diſpoſed into three claſſes: the firſt of which "claſs is compoſed of ſix, annexed to the "head, near the breaſt: the ſecond conſiſts of "eight, on the belly; and the third of only "two, joined to the extremity of the body. "The firſt ſix legs have each a claw; the "other ten have each many crooked ones." This is enough, as to the outward form.

In order to diſcover plainly that a Butterfly is encloſed and hidden in the ſkin of this Caterpillar, the following operation muſt be uſed; One muſt chooſe a full-grown Caterpillar: tie to its body a ſmall thread, and then put it into boiling water, and take it out ſoon after. Thus its external ſkin will ſeparate; becauſe the fluids, between the two ſkins, are by this means rarefied and dilated, and therefore they break and ſeparate both the veſſels and the fibres, wherewith they were united together. By this means the external ſkin of the Caterpillar, being ſpontaneouſly ſeparated, may be eaſily drawn off from the Butterfly, which is contained and folded up in it. This done, it is clearly and diſtinctly ſeen, that, within this ſkin of the Caterpillar, a perfect and real Butterfly was hidden. Therefore the ſkin of the Caterpillar muſt be conſidered only as an outer garment, containing in it parts belonging to the nature of a Butterfly, which have grown under its defence by ſlow degrees, in like manner as in all other ſenſitive bodies that increaſe by accretion.

But as theſe limbs of the Butterfly, which lie under the ſkin of the Caterpillar, cannot, without very great difficulty, be diſcovered in the full-grown Caterpillar, unleſs by a perſon accuſtomed to ſuch experiments, becauſe they are very ſoft, tender, and ſmall, and are moreover complicated or folded together, and encloſed in ſome membranaceous integuments; it is therefore neceſſary to defer the execution of the operation, juſt now propoſed, until the ſeveral parts of the Butterfly become ſomewhat more conſpicuous than at firſt, and are more increaſed and ſwelled under the ſkin, by force of the intruded blood and aqueous humour. This is known to be the caſe, when the Caterpillar ceafes to eat, and its fkin on each fide of the thorax, near under the head, is then obferved to be more and more elevated by the increafing and fwelling limbs, and fhews the appearance of two pair of prominent tubercles.

That it may be known at what time the changes in the Caterpillar comes on, exactly and regularly, I fhall proceed to explain the fourth figure, N°. IV. This defign exhibits the Caterpillar fwoln, *a b*, all about the fecond and third rings of the body; whilft, in the mean time, the reft, that is, the lower part of the body and the tail, are confiderably diminifhed and contracted, *c*. This is the beft ftate in which to fkin the Caterpillar, which I would have well obferved; for it is for this reafon only I have faid before, that, in order to make the intended experiments, one muft chufe a Caterpillar when near the time of changing its fkin: fuch is that which I delineate in this figure.

To explain in a clearer method this fundamental propofition, that the Butterfly is contained in the Caterpillar; or, otherwife, that the Caterpillar is the Butterfly itfelf; we muft carefully obferve, that after all the limbs of the Butterfly are fufficiently increafed within the external fkin of the Caterpillar, wherewith they are yet kept invefted, the Caterpillar at length, when about to undergo its change, betakes itfelf to fome retired place, in which it may fecurely caft off its outward fkin. With this defign the Caterpillar firft fixes itfelf, by only a thin and flight web, to a board, tree, plant, wall, beam, N°. IV. *dd*, or any other folid fubftance; and after this, fixing the claws of its two hinder legs in this web, *e*, it immediately fpins very carefully a ftrong double thread, or ligament, which it draws acrofs its back, and faftens it with the former fuperficial web againft the beam or wall in two diftinct places, *ff*: fo that the fore-part of the Caterpillar's body hangs in this ligament as in a wreath; whilft, in the mean time, the hinder part lies fixed in the fuperficial web, faftened to the beam.

In confidering this Caterpillar, it muft be carefully obferved, that it lays the faid wreath fomewhat obliquely, and about the fore-part of its body. And hence it happens, that when the fkin of this Caterpillar, lying under this wreath, is turned back and caft off, the wreath itfelf is not thrufted more towards the hinder parts than to the middle of the body; it being there faftened a little to the foft fkin, and dried. Hence this remarkable advantage arifes to the Caterpillar, when ftript of its fkin, that it hangs, as it were, in equilibrio. The Caterpillar, having thus difpofed all thefe matters with this appearance of judgment and difcretion, is obferved to ceafe all action and motion of its limbs, and to compofe itfelf in the moft profound reft.

Immediately afterwards, or within the fpace of twenty-four hours, about the fore-part of the head, it may be obferved, that its limbs, being now fully enlarged under the fkin, begin, by the very flow and gentle tranfportation and appulfe of the blood and humours, to be diftended, extended, and inflated in fuch a manner, as to fwell even beyond the level of the fkin, and, by thus raifing the fkin, it ftretches it, and makes it fhine. On the other hand, it is obferved, that, at the fame time, the hinder parts of the Caterpillar's body decreafe in fize in their turn, in the fame meafure, and exactly in equal proportion, and become regularly fo much fmaller. Hence all power of motion is immediately taken away from the fixteen legs of the Caterpillar, fo that it can afterwards neither creep nor ftand.

At length this inflation or fwelling of the limbs, and other parts, which are at this time forming themfelves, and, as it were, budding out into a Chryfalis, proceeds fo far, that the external skin opens on the back, and afterwards in three diftinct places in the head, and begins to be drawn off, and rolled away from the fore towards the hinder end of the body: and, by this means, all the limbs enclofed within prefent themfelves to view. Thefe limbs and parts, being then difpofed, according to a certain neceffary order, and unchangeable rule of nature, the creature affumes the form of a Chryfalis, reprefented under No. V. This Chryfalis is an infect without motion; and indeed it cannot be otherwife, for its limbs are all incapable of motion: this is neceffarily occafioned by the impelled blood, and other humours, diftending them: add to this, that the limbs are drawn downwards by the feparating skin, and a great part of them likewife are extended. Nor indeed is this skin drawn off eafily; nay, not without great labour and difficulty: for all the complications of fibres, by which the upper is joined to the under skin, are then broken. For this reafon alfo, the Caterpillar draws itfelf at that time one way and another, with an undulatory motion, and by the tremulous palpitation of the rings of its body. By this violence, at length, a limpid kind of ichor or humour is diffufed between thefe two skins, and the Caterpillar then, at length, cafts off the the old one. This procefs is perfected very expeditioufly, after the opening is made in the fkull. Thus I have briefly, but exactly, defcribed how this Caterpillar affumes the form of a Chryfalis; the feveral parts of which are however feen with greater difficulty, than thofe of the Nymph.

On the other hand, when this Chryfalis, or rather, to fpeak properly, the involved Butterfly, is drawn out of its fkin, by means of hot water, it has a quite different form, as may be feen in Figure II. where it is reprefented laid on its belly: and this is yet more perfectly illuftrated in Fig. III. which prefents it lying on its back, fhewing thus all its limbs. But becaufe thefe delicate parts cannot be fo well diftinguifhed by thofe who are unaccuftomed to fuch refearches, in order to reprefent them the more plainly, I have delineated them, and marked them with diftinct letters in Fig. IV. It may eafily be obferved there, how that Butterfly, which I have drawn out from the fkin of the Caterpillar, is provided with all thofe members,

members, which are feen in the Butterfly, delineated in No. VI. As the two horns on the head, *a a*; the double curled probofcis or trunk, placed in the lower part of the head, between the horns, *b*; and four wings fituated on the two fides of the thorax, *c c*; between which are likewife feen fix legs; and laftly, the abdomen divided by its annular fections, *d d*. All thefe things appear fo clearly and diftinctly to the eye, in a natural example, that there is not the leaft room to doubt the truth of the fact. This is the very creature intimated in No. V. and called in that ftate an Aurelia, or a Chryfalis; tho' it fcarce expofes to our view any parts, which agree with the creature of the fourth Figure: yet it has no other than the fame limbs and parts, only they are difpofed in a different manner, as I fhall explain hereafter. It will then likewife appear that thofe, which I reprefent feverally in this Tab. XXXVII. are all but one and the fame creature, only hidden, as it were, under different forms; and this is likewife the cafe in man, if we confider the original egg, with its coverings, the navel ftring, and its feveral changes; as I fhall explain at large hereafter.

To fhew moft diftinctly the difference between the Butterfly drawn out of the fkin of the Caterpillar, and reprefented in Fig. III. and the fame Butterfly, when called a Chryfalis, or Aurelia, as delineated in No. V. It muft be obferved, that the real difference confifts only in this, that the limbs, that is the legs, wings, &c. are ranged and difpofed in the Chryfalis, according to a certain order and neceffary rule; and, on the other hand, that thefe parts are by art rudely unfolded, and turned out in the Butterfly, drawn from the fkin of the Caterpillar, and removed from their natural fituation, which they obtain firft under the fkin of the Caterpillar, and afterwards in the Chryfalis.

Hence the Chryfalis, No. V. is nothing elfe but the Butterfly expreffed in Fig. III. the expanded parts of which are folded, and difpofed among one another in a different form and order.

It muft be at the fame time carefully obferved, that thefe limbs, and other parts, are found to be of three diftinct magnitudes: for, in the Caterpillar, No. IV. the limbs are ftill fmall, and concealed entirely under the fkin; and then in the Caterpillar, or Butterfly, ftripped of its outer fkin, Fig. III. they are extended much larger; and laftly, in the Butterfly, under No. VI. they are larger. Yet this obfervation muft be particularly attended to, becaufe the three creatures, juft now mentioned, are one and the fame, and their limbs and parts alfo are the fame. But as to the larger or fmaller fize of them, that depends only on the blood and humours, which being moved in the limbs, has at length extended them as much as poffible. In the creeping Caterpillar, it was not poffible for thefe members to increafe much: and in the full-grown Caterpillar, they could not be produced further than the fkin was capable of being diftended: but under the form of a Chryfalis, there has been a confiderably greater extenfion; fince the external fkin is there caft off, and thefe parts have acquired another form. However, they are not yet arrived to their full fize; fince the laft fkin, which the Chryfalis muft throw off, could not be extended further than the folds and wrinkles, into which it was contracted, could give way by unfolding or difplaying themfelves. It happens in this ftate, that the creature neceffarily wants all that motion, which it had before under the form of a Caterpillar, and muft reft for fome days, until the blood and humours, with which its limbs were filled and diftended, are diffipated fufficiently by means of an infenfible evaporation, and then the faculty of moving is reftored to it.

Hence, therefore, it is certainly and clearly evident, that one animal is here, as it were, hidden or enclofed in another: nay, that the Caterpillar and Chryfalis are the Butterfly itfelf, but enclofed or covered by an hairy and cutaneous coat; and fo altered by the different difpofition of the parts, that it cannot yet be known. This is the fact which I propofed to demonftrate. And nothing further now remains, but to defcribe the difpofition of the limbs under the fkin of the Caterpillar, No. IV. for which purpofe, I muft compare thofe parts one with another, as they are conftituted in the Chryfalis, under No. V. for thus it will be evident, how the members of the Butterfly, drawn out of its fkin, are difpofed as well in the Caterpillar, as in its Chryfalis.

As therefore the difpofition and arrangement of the parts in the Butterfly-Chryfalis, is found, in No. V. to be worthy of the greateft admiration, I fhall obferve, that thefe fame parts are not lefs admirably difpofed in the Butterfly, when drawn out of its fkin, Fig. IV. this perfect animal being at all times hidden and enclofed in the Caterpillar, No. IV. The legs, which in the Butterfly, at the time it lies in the Chryfalis-ftate, are ftretched between the horns, and placed on either fide in the breaft near the trunk, are in the Caterpillar fomewhat curled and complicated under the fkin of the fix fore-feet of that creature: for, as the impelled blood could not equally extend them in that part; they therefore appear there fomewhat wrinkled and inflected: that continues until the fkins are at length caft off, and they are again extended as much as poffible, in the Butterfly-Chryfalis; and whilft the fkin is outwardly drying, they are joined one with another.

The wings, which in the Chryfalis-Butterfly, are evidently extended in each fide of the breaft near the horns, are placed under the fkin of the Caterpillar, near the under legs of the firft clafs; nay, their ends are enclofed in the fkin of the fame legs. This ought to be carefully obferved; fince this is the only reafon why, when the Caterpillar is changed into a Chryfalis, the limbs are neceffarily thus, and not otherwife, difpofed: for thefe legs and wings are, at the time the old fkin is cafting off, drawn downwards, together with the fkin in which they lie, and are then regularly difpofed on the breaft, near to and between each other: and this is performed with fuch great art, and in a manner fo fingular, that this

this subject only, might supply matter for a whole treatise.

The horns, which in the stripped Butterfly, that is already changed into a Chrysalis, are extended and situated between the legs and wings on each side on the breast, so as to touch at the same time the trunk with their extremities, are, in the Caterpillar, hidden under that part of the head which constitutes the skull; and these thrusting themselves up out of the head, are very closely folded together, and, by a particular convolution afterwards, represent a serpentine winding. Their extremities are likewise closely twisted into one. Hence the horns in the Chrysalis could be extended above the breast, on the casting of the skin. This I have already, with respect to the Chrysalis of the coloured Butterfly, more accurately demonstrated, magnified in the explanation of Tab. XXXV. It will be proper to compare this history with that, and to read them together, because the one throws great light upon the other.

The trunk, which, in the Butterfly stripped of its skin, and changed to a Chrysalis, is stretched along, and situated on the middle of the breast between the legs, horns, and wings, is found to lie wonderfully complicated, under the skin of the creeping Caterpillar, between some bristly and articulated hairs, situated near the lower part of the mouth. These very bristly hairs, and the trunk, are also found regularly disposed in their respective places in the Aurelia, after changing the skin.

Lastly, the belly and tail, which in the Butterfly, when it represents, Tab. XXXVII. No. V. a Chrysalis, are found shortly contracted and drawn together, are in the Caterpillar, No. IV. extended through the greatest part of the skin of the body. In the hidden Butterfly, or creeping Caterpillar, No. III. all that part of the body chiefly, which is extended from the fore-legs to the hinder extremity, must be accounted the belly and tail; and at the time this creature is changed into a Chrysalis, it loses all its ten hinder legs, without exception.

But, as it is not enough for me to have exhibited and described the most profound mysteries of nature, as I have done hitherto; so, at the same time, I think myself obliged to communicate to the reader, the management by which I was enabled to find out in the hidden Butterfly, the disposition of its limbs under the skin of the Caterpillar: since these limbs are there soft, tender, and almost fluid like water; and therefore, when any one draws off the skin from them, they are most easily removed from their natural situation.

In order therefore to provide against this, and that the parts of the Butterfly, Fig. IV. hitherto described, which lies under the skin of the Caterpillar, No. IV. may be viewed to satisfaction, and seen as they are naturally disposed, we must take care, that these parts be first hardened under the skin, to such a degree, as that they will not lose their natural situation afterwards, when the skin is taken therefrom. This is done very conveniently, if a Caterpillar, which is going immediately to cast its skin, be put into a bottle full of a liquor composed of equal quantities of spirit of wine and vinegar; for, as the Caterpillar is very easily killed by this liquor, its limbs also will harden therewith, in the space of fifteen or sixteen hours. Therefore, if the Caterpillar be afterwards carefully skined, the disposition, and several foldings of the limbs of the enclosed Butterfly, may be very beautifully seen, as they lie under the skin of the Caterpillar.

I shall now proceed; and, in order to set this matter in the clearest light, I shall exhibit also, by distinct letters in Fig. v. all those limbs and parts of the Butterfly which I have demonstrated in Fig. IV. or those that are already described in the Chrysalis under N°. V. That is, I shall now likewise shew, in the Chrysalis or Butterfly, which hath spontaneously changed its skin, all the parts which I have before shewn in the Butterfly, drawn out of the skin of the Caterpillar by art: for the creature, which I represent in Tab. XXXVII. Fig. v. is the same which I have already delineated under N°. III. In this are first seen the horns, Fig. v. *a a a a*, distorted from their natural situation: then are observed the two parts of the trunk, which, arising below out of the head, and running over the breast, are terminated, *b*, on the lower part of the body; where they are likewise, but not much, deflected or bent out of their natural situation. Next are discovered, on each side, two legs, which, being removed out of their natural situation, I have placed on each side of the upper wings, *c c*. The other two legs are not here represented, since they may be plainly and more easily exhibited lying under the trunk and wings in the insect itself, than they can in this figure. Under these two pair of legs the upper and lower pair of wings come likewise in sight, though only a part of the lower appears to the eye, *d d*, because they are covered in great part by the upper pair. All these four wings are likewise drawn out of their situation. The head and eyes, *e*, are seen above, and the tail and the annular divisions of the belly below, *f*. However, one can see all these things but obscurely, for two reasons: first, because these limbs, being placed in this manner in the Chrysalis, are disposed in a peculiar order; and because they are, in that state also, grown stiff and hard, by the power of the air. But it is easy to discover the same limbs of the Butterfly in all the Aureliæ, and to separate them from each other; provided one has first steeped them for a little time in hot water.

I shall now likewise exhibit, in Fig. VI. all the limbs and parts hitherto enumerated, as well of this as of the creatures represented above, since they are all but one and the same creature. There is this difference shewn in the present figure, that I have stript the limbs, which I now present to view, of their last skin, wherein they were kept still rolled up: so that we here now view this insect clad, as it were, in its perfect outside, which is never cast off, and is abolished only by death. But as in cast-

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ing the laſt ſkin, there is as much art obſerved as in the drawing off of the external skin of the Caterpillar; I ſhall here briefly explain the whole order of this laſt change, or the ſudden ſwelling out of the limbs.

In the VII Figure I exhibit the Butterfly, the limbs of which were before repreſented in the IV Figure, and as having put on the form of a Chryſalis, delineated under No. V. And this Chryſalis being very near its metamorphoſis, is in that ſtate every moment ready to caſt its laſt skin. If any one deſires to know, by what means it can be known, that this change is very near; let him obſerve, that this may be certainly known beforehand by thoſe black ſpots, which are obſerved to appear through the skin of the Chryſalis, at the ends of the two upper wings; and therefore I delineate one of thoſe pellucid ſpots in the left wing of this Butterfly-Chryſalis.

In order to underſtand the method, whereby this laſt change of the skin is performed, it is neceſſary to know, that after the encloſed limbs of the Butterfly, have by degrees acquired their full ſtrength, by the help of an inſenſible perſpiration, it at length, by agitating and moving itſelf, and by drawing its breath with greater force, breaks open the external skin with which it is ſurrounded, in three or four different places, and diſplays looſe and free its hitherto united parts.

When the inveſting skin juſt begins to open, it is obſerved, that the ſtrength of the encloſed Butterfly is likewiſe increaſed. And hence it then immediately thruſts its horny trunk and legs out the skin, and fixing the claws of its feet to the adjacent objects, or to its own caſt skin, it thus, as it were, by force, diſengages itſelf from this laſt covering. Thus at length it creeps out of its skin, formed in the manner exhibited in the ninth Figure. Nor does its appearance then differ much from that which it had, when drawn out of the skin of the Caterpillar by art, as may be ſeen by the Figure.

I deſire leave to obſerve here, that the creature ſcarce retains this form a moment; for as ſoon as the skin is regularly broke open, and the Butterfly juſt begins to creep out of it, immediately its wings begin to increaſe, and they grow wonderfully faſt. Before I treat this matter more fully, I muſt obſerve what I have hinted at in the preceding ſheets; that is, that the limbs, and eſpecially the wings of the Butterfly, are of three diſtinct ſizes: they are ſmalleſt when they lie in the Caterpillar, delineated under No. III. and then in the Butterfly, drawn out of the skin of the Caterpillar, as in Fig. IV. they were obſerved ſomewhat larger; and laſtly, they have acquired their third and full magnitude, when, by the impelled blood and humours, they have been orderly ſituated in the Chryſalis, delineated No. V. But even then, they could not extend themſelves further; becauſe the laſt skin that remained to be caſt off, did not permit it.

Therefore, when theſe laſt skins are caſt off, it is at length ſeen, how theſe wings increaſe, ſwell, and are expanded in a moſt wonderful manner, by the force of the blood, humours, and impelled air: this is exhibited in the X Figure. When any one has for ſome time conſidered this matter in the Butterfly itſelf, he will ſay that it is like a drop of water, which, when it falls on dry paper, dilates the paper, and makes it unequal, thick, and full of holes. In the ſame manner, indeed, theſe wings, which are in the beginning rough and full of wrinkles, and unequal, fold and expand themſelves, until at length they become ſmooth, and they are then twelve time times as large as they were in the beginning. This may be ſeen in No. VI. where I repreſent the wings fully and perfectly expanded, and in their natural ſize.

What deſerves moſt admiration is, that all this accretion of the wings, great as it is, does not take up the ſpace of a quarter of an hour. And beſides, what is very conſiderable is, that if at this time a part of the growing wings be cut off with ſciſſors, they manifeſtly diſcharge blood more or leſs copious, according as the wing is wounded at a leſs or greater diſtance from the body. This blood, which is yellowiſh, diſtils in ſmall globules out of the wounded veſſels, and the wing never afterwards expands itſelf properly. But theſe wings, being once wholly extended and dried, will never afterwards diſcharge any blood, though they be wounded ever ſo often. Hence it is evident, that this creature, in the ſpace of a quarter of an hour, is ſent forth from the Chryſalis in every reſpect perfect *, ſo that it never afterwards wants a further accretion, nor is ſubject to the miſchances of infancy.

In what manner theſe wings are in reality expanded, and how their black ſpots are diffuſed from ſmall into large ones, and how all the colours of theſe wings are increaſed, and are all together equally changed by the ſame motion; theſe, with other innumerable curious and wonderful myſteries of nature, I ſhall, if it pleaſe God, explain hereafter in a treatiſe expreſly on that ſubject: and I ſhall then ſhew how one may view, as clear as the light at noon, the reſurrection of the dead, and the happy ſtate of thoſe that are brought to life again, in this little inſect.

I ſhall finally in this place briefly lay before the eye, the limbs of the Butterfly, and the increaſing wings in a rough draught, and afterwards conclude this hiſtory. Firſt, in the head are ſeen two reticulated eyes. Over theſe are obſerved two horns, Fig. XI. *a a*, divided into their joints, and adorned with white, yellow and

* The whole operation in the diſcloſure of the Butterfly from its Chryſalis, is full of wonder; but in no part ſo much as in the expanſion of the wings. From the folded and complicated ſtate wherein they lay in the Chryſalis, they diſplay themſelves ſo ſuddenly, that the firſt obſervers thought they were ſmall at that time, and grew thus ſuddenly. The ſubſtance of theſe wings is membranaceous, and the duſt which covers them is compoſed of regular little parts, called by ſome feathers, and by others ſcales; but neither properly. They have footſtalks, and they are of various figures, oval, round, oblong, and indented. On theſe depend the colours of the wings. The veſſels which ſupport the filmy ſubſtance of the wing, contract as ſoon as the wing is expanded; for, till then, they are tubular. They are like the navel-ſtring in the human body; at firſt vaſcular, but afterwards ſolid. The edges of the wings are ſupported by a ſtrong rib, and fringed with theſe feathery ſubſtances.

blackiſh ſcaly feathers. Between theſe, one may perceive how the Butterfly rolls its trunk, *b*, which it ſome time afterwards hides between the forks. In the thorax, the two upper wings *c c* preſent themſelves, which are almoſt every where covered with white little feathers, and in ſeveral places are variegated with thinner, feather-like yellow ſcales: even the black ſpots, which adorn their extremities, are compoſed of ſimilar ſmall feathers. The ſame likewiſe is the condition of the two under wings, *d d*. Six legs likewiſe appear, *e e e e*, which are increaſed to a much greater length than they had either in the Caterpillar, or in the Butterfly, drawn out of that ſkin: but in this laſt change of the ſkin, the legs are increaſed no more; ſince they have already acquired their full bigneſs in the Chryſalis. Laſtly, the tail and abdomen are ſeen covered with their rings, hairs and feathers, *f*. It is likewiſe obſervable, that all theſe colours may be wiped off the wings in ſuch a manner, that only a thin, delicate, and tranſparent membrane remains. And now, can any perſon, who rightly conſiders theſe divine miracles, help admiring them, and agreeing, that they are moſt truly ſuch? Indeed this remarkable hiſtory very ſtrongly evinces, that the moſt wiſe and merciful God, is manifeſtly known from his viſible works: ſince thoſe inſtances of this power which are remote from our ſight, become evident from thoſe we ſee; that the eternal nature of God is therein diſplayed clearer than the meridian ſun. Their offence therefore is inexcuſable, who have either lived inſtructed by the law of nature only, or have known the law of Moſes, and the goſpel of Chriſt; for, according to theſe, all men ſhall be judged, and ſhall be either abſolved or condemned.

The FOURTH ORDER.

Of natural changes, or ſlow accretions of the limbs.

HAVING now explained the more ſimple and intelligible modes or methods of theſe changes, I ſhall proceed to the compound, and more obſcure, which ſeem indeed wholly incomprehenſible; but in reality, all the inſects of this fourth order, of which I am now to treat, the changes of which I have hitherto obſerved, are changed into real Nymphs, entirely like thoſe of the firſt ſpecies or method of the third order. Therefore we may refer all the Nymphs belonging to this fourth order, to the Nymphs of the firſt mode of the third order: for though the Nymph of the fourth order, does not ſo clearly exhibit its limbs to view, as that of the firſt and ſecond order; yet they are more diſtinctly viſible, than in the Chryſalis belonging to the latter mode of the third order. Hence this Nymph muſt be rightly and properly reckoned among thoſe, which I have delineated and deſcribed under the firſt method of the third order; ſince the former exhibits its limbs as clearly as the latter.

To thoſe who examine this Nymph more accurately, there likewiſe occurs a conſiderable and important difference, which conſiſts in this, that this creature does not caſt its ſkin, but is changed within it, and without parting with it, into a Nymph. Hence it is, that on account of this difficulty of diſtinguiſhing the parts of this Nymph, I am obliged to add a fourth order, to comprehend this peculiar kind; though in reality the intrinſic Nymph of this fourth order, is exactly like the external Nymph of the third order, and is of the ſame nature and diſpoſition with the latter, without any difference.

In order to place this matter in as a clear a light as poſſible, it is neceſſary to obſerve carefully, that even in the worms, which undergo the changes of this fourth order, the limbs increaſe ſlowly under the ſkin, in the ſame manner as in the already mentioned Nymphs of the third order; and are there diſpoſed in like manner and order under the ſkin, as they are found arranged under it, in the Vermicles or Worms of the third order; but there is, however, a conſiderable difference, by which, as by a criterion, or certain ſign, one may diſtinguiſh theſe two Nymphs of the different orders from each other. It conſiſts in this, that the Nymphs of the fourth order do not at all exhibit to view their limbs, nor make them viſible at any time: for, as the Vermicles, or Worms, which are changed into Nymphs of the third order, caſt their ſkins, and afterwards preſent to outward view all their limbs and parts, which had been before hidden under them; on the other hand, the Vermicles or Worms belonging to this fourth order, do not caſt, but retain the ſaid ſkin. And hence, as the Nymphs of the third order, when they are afterwards about to put on the form of real Nymphs, caſt only one ſkin; theſe interior Nymphs of our preſent fourth order, at the ſame time caſt off two ſkins or membranes, whereof the outer is much thicker than the inner. This is what conſtitutes the eſſential difference I have named, between the Nymphs of the third and thoſe of the fourth order, which are perfectly alike in all other reſpects.

It is very wonderful here, that ſome of the Vermicles, or Worms, which are referred to our fourth order of changes, preſerve their original and external form entirely unaltered; whilſt, on the other hand, others in great part loſe it. But theſe, though they do thus far deviate from them, yet they never entirely loſe all the marks of the former Vermicles, or Worms; for they retain, as it were, the figure of Vermicles, or Worms: and in this very figure, or, to ſpeak more forcibly, in their proper ſkin, which they do not caſt off, they become immoveable; and there ſhooting out new limbs, they at length put on the form of real

Nymphs.

Nymphs, within their uncaſt ſkin. And this change is, therefore, almoſt like that undergone by the Vermicle, or Caterpillar, which is changed hidden within its web, and out of ſight, as is properly and truly alledged by Mr. Ray. Vid. Catalog. Plant. circa Cantabr. naſcent, P. 137.

Since, therefore, the Worm either retains its own proper figure entirely, or deviates a little from it; but which ever of the two forms it puts on, yet always increaſes into a Nymph within its uncaſt ſkin. Hence it is, that I think it very reaſonable to denominate this change by the appoſite appellation of a Nymph-Vermicle; for the Worm, having ſtill retained its outer form, acquires the true nature of a Nymph in its uncaſt ſkin. Before I further explain in what manner theſe worms, which either retain their form or partly loſe it, are conſtructed internally, I ſhall offer ſome general obſervations on the eggs, ſmall animals, Worms, and Nymphs in each of the four orders, and compare all thoſe proceedings of nature together. This, indeed, will contribute greatly to the underſtanding of this our fourth order.

With reſpect to the eggs of the Inſects in the firſt order, it muſt be obſerved, that the ſmall animals encloſed in them are like the Nymphs of the fourth order; and are ſurrounded or covered with their regular inveſting ſkin, in the ſame manner as the Nymphs of that order are involved in the ſkin of their Worms: ſo that, by reaſon of this integument, one can by no means diſtinguiſh the ſeveral parts. But the Inſects of the firſt order, without any intermediate change, directly iſſue perfect out of the ſhells of their eggs; nor are they cloathed like Worms firſt, nor do they attain the full term of their increaſe before they are hatched. And hence it is, that they are not afterwards changed into immoveable Nymphs, but only caſt their laſt ſkin: and it is therefore for this reaſon I call this change, at that time, a Nymph-Animal.

Moreover, in regard to the eggs of the ſecond order, it muſt be obſerved, that the Worms contained in them are likewiſe inveſted with ſuch a ſkin as thoſe of the firſt order, and that there are likewiſe properly Nymphs in it; but they iſſue from thence imperfect, in reſpect to all their limbs and parts, which afterwards inſenſibly increaſe externally in their body: and, for this reaſon, the Worm precedes that change of them, which I call the Nymph-Animal. And hence this ſecond order conſiderably differs from the firſt, in which the animal iſſues perfect out of its egg. But theſe two orders agree alſo in this, that, in both of them, the animal increaſes into a Nymph, whilſt it is moving and walking about; and this Nymph alſo is, without loſing its motion, at laſt changed, and it caſts a ſkin.

The eggs of Inſects of the third order are likewiſe inviſible Nymphs, which are placed there without food: ſo that, in this reſpect, all theſe three ſpecies of eggs agree. But the Worms, which, in this third order, creep out of the eggs, differ ſtill more, in regard to the perfection of their parts, from the Worms of the ſecond, than thoſe of the ſecond order do from the ſmall Animals of the firſt. For all the limbs of the ſmall Animals of the third order do not grow out of the ſkin, but, in a concealed manner, under the ſkin; for which reaſon they are removed from our ſight, until at length the creatures, having caſt their ſkin, and changed their original form, preſent all theſe things to view externally. Beſides, about this time, theſe Inſects entirely loſe all motion; and then put on a-new the ſame habit which they had before in the egg. This change I call the Nymph and Chryſalis, as being a third ſpecies, different from the firſt and ſecond order. However, all theſe three orders reſemble each other in this, that the eggs of each are Nymphs at firſt: and the ſecond order yet ſpecifically anſwers to the third in this, that, in each of them, the change into a Nymph is preceded by a Worm or Caterpillar.

Laſtly, the Worms of the fourth order are, in their eggs, likewiſe plainly Nymphs, whoſe limbs and other parts are ſo involved in the ſhells of the egg, that they can by no means be diſtinguiſhed: wherefore thoſe Worms thus far agree with the eggs of the firſt, ſecond, and third order. But theſe differ from the little creatures which iſſue from the eggs of the firſt order, in that they break, as imperfect Vermicles or Worms, out of their eggs. They likewiſe deviate from the Worms of the ſecond order, in that their limbs do not grow externally, but within their ſkin: and, in this reſpect, they again exactly anſwer to the Worms and Caterpillars of the third order. However, they differ alſo from thoſe of the third order, in that they never preſent their limbs, in this ſtate, to outward view; but are changed into Nymphs within their ſkin, which they never caſt off, but become immoveable therein. By this means they, in reality, aſſume a ſecond time that form which they before had in their eggs; and therefore I call this change the Nymph-Vermiform, as being entirely different from that of the walking Nymphs in the firſt and ſecond order: though, with reſpect to all the parts, it anſwers to the Nymph of the third order, only that it is inviſible. It agrees likewiſe with the ſecond and third order, in that the Worm precedes the final change: whereas, on the contrary, there iſſue out of the eggs of the firſt order of Inſects creatures like their parents, nor does the Worm-ſtate precede their Nymphs.

This matter being underſtood, it is clearer than the light at noon, how far thoſe eggs, ſmall Animals, Worms, and Nymphs of the firſt, ſecond, third, and fourth orders agree, and in what they diſagree one from another; and alſo what is accidental, as it is called, in each, and what is eſſential to their ſeveral natures. Indeed, when theſe things are rightly obſerved, there is nothing in our fourth order of tranſmutations which may not be clearly and eaſily underſtood; ſince the whole conſiſts in in this, that the Nymph remains hidden under its ſkin, which it never caſts; nor does it even, at any time, preſent itſelf externally to view: that is, this Nymph lies hid in its Nymph, in the ſame manner as the little creature of the firſt order does in its egg, in which it is likewiſe an inviſible Nymph; or as the Worms of the ſecond and third order, which are likewiſe inviſible Nymphs in their eggs; or, laſtly, as the Worm of this fourth order, which is likewiſe an inviſible Nymph, while in its egg. The eggs of all the four orders entirely agree, in general and in particular, with the change of the Worm of our fourth order into a Vermiform Nymph.

Having conſidered ſufficiently what has been ſaid, I ſhall proceed to explain how it happens that the Worms, belonging to this fourth order of changes, do more or leſs deviate from the original form of the Worms, though they do not by any means caſt their ſkin. In order to explain this clearly and diſtinctly, I muſt firſt obſerve, that ſome of the Worms which belong to the fourth order of changes, are provided with hard, tenacious, and ſtrong ſkins; and others, on the contrary, have thin, ſoft, and flexible ſkins. This diverſity of ſkin not only makes the tranſmutation of form more or leſs remarkable, but renders it ſo obſcured in the Worms inveſted with a ſoft ſkin, that it becomes entirely incomprehenſible and inextricable. On the other hand, when the Worms are covered with a hard ſkin, we ſee nothing of this kind happens; for as their external tenacious ſkin cannot form and accommodate itſelf to the internal change, which the body of the encloſed Nymph undergoes, that ſkin neceſſarily retains the figure of a Worm, and reſembles it as exactly as if it were ſtill alive.

When the Worms, which I have referred to the firſt ſpecies or method of the fourth order of changes, have eaten ſufficiently, and their limbs are increaſed to the proper degree under the ſkin, they ſeek a proper place for themſelves, wherein they may ſafely and quietly iſſue into a Nymph. After this they reſt for ſome time, until they inſenſibly loſe all their former motion. But they are not even then conſiderably contracted, nor do they become ſmaller, or are they changed in form; though, in the mean time, they put on the form of a real Nymph within their uncaſt ſkin.

Hence, therefore, we draw this important concluſion, that the inſenſible perſpiration, which I have aſſerted to obtain univerſally in the Nymph, may, in this example, be ſeen, as it were, with our eyes: for, in the Worms of this firſt ſpecies, it is obſerved, that the Nymph fills the whole ſkin of the Worm. But this Nymph afterwards, changing colour in a manner not perceivable by the ſenſes, and contracting itſelf by degrees, inwardly recedes on each ſide from the extreme ends of the ſkin, and conſequently then fills only a part of it. And this proceſs continues, until the Nymph, being more and more contracted, by reaſon of the evaporation of the ſuperfluous humours, manifeſtly forms in the uncaſt ſkin of the Worm two very conſpicuous cavities, one towards the head, and the other towards the tail and belly of the ſaid Nymph; and theſe cavities become afterwards larger and larger, until the creature has acquired its perfect ſtrength. The very experienced Dr. Harvey. has obſerved ſomething like this, concerning the little cavity in hens new-laid eggs; for this alſo is inſenſibly inlarged afterwards, by the evaporation of the fluids.

Wherefore, when the skin is hard and tough in theſe Worms, or when it grows ſomewhat hard at the time the Worm is inwardly obtaining the form of a Nymph, the former figure of the Worm muſt neceſſarily remain entire: whilſt, in the mean time, the little creature puts on the form of the Nymph within the hardened skin, from which it is more and more inſenſibly ſeparating; as I ſhall afterwards very clearly demonſtrate, in the figures of my fourth order. The ſeveral obſervations which I ſhall ſubjoin to theſe, will indeed render this matter yet more clear and intelligible; for I preſume boldly to appeal to thoſe obſervations particularly, ſince I have employed thereon all the induſtry I was capable of.

As to the ſecond method of the changes in this fourth order, it comprehends thoſe Worms which are covered with a ſoft skin; and it offers one thing to be conſidered particularly, which is, that the external skin accommodates itſelf to the body of the Nymph which is inwardly changed. But becauſe this internal tranſmutation of the little Body or Nymph becomes of the ſhape of an egg, in many ſpecies of theſe Vermiform-Nymphs, therefore the external skin alſo, which is not caſt off, then neceſſarily acquires an egg-like figure. By this means theſe Worms alſo are changed into ſuch Nymphs as do not caſt their skin. The Nymphs, which are ſubject to this method, are very complicated and difficult to be known, beyond all the reſt of the fourth order, as their Worms have a very delicate and tender ſkin. Theſe Nymphs, for that reaſon, recede leſs from the form of their Worms than thoſe in which their ſkin is ſomewhat thicker; ſo that the hardneſs or thickneſs of the ſkin makes the change plainer, or more obſcure to us.

However widely theſe Nymphs differ from the prior form of their Worms, they all preſerve various traces of that form. In the firſt place, they retain the ſkin uncaſt; and the annular inciſions, the head, tail, and the reſt, are preſerved or altered, according as they more or leſs deviate from the form of Worms. Some alſo have appearances like legs, horns, and other marks. For theſe important reaſons, I give them all promiſcuouſly the name of Vermiform-Nymphs; though I very well know that they have been called eggs by ſome induſtrious ſearchers into nature, as Mouffet, Goedaert, the illuſtrious Mr. Ray, and lately by the very learned Francis Redi, as if no diſtinct limbs could be obſerved in them. But are not theſe the very Worms themſelves, which have within that skin ſprung up, or budded into Nymphs, by means of the accretion of the limbs? For what reaſon then, or with what right, can we call them eggs? But, beſides all this, the gentlemen now mentioned do not conſider theſe eggs as real animals, but only as ſhells filled with a liquid, out of which the animals are at length to be generated by a ſtrange and miraculous transformation. Hence we alſo obſerve, that Mr. Ray alſo, in his catalogue of the Cambridge plants, with great reaſon doubts, whether the Chryſalis be hidden in the egg which they ſpeak of; at the ſame time confeſſing, that they want a proper word to expreſs this transformation. As this author aſſerts a little before, that theſe eggs have the ſame relation to the Flies as the Aurelia have to Butterflies, he certainly commits a great error: for the Aurelia is the inſect itſelf; but theſe eggs, as they are called, are only the Worm's skins unſeparated, in which is contained not a Chryſalis, but a real Nymph; which clearly and diſtinctly repreſents to the life all its limbs, as may at any time be demonſtrated by us. To this we are to add, that there is no total tranformation in this egg, as they imagine to be the caſe in the Chryſallides. However, it is ſufficient for me to have ſet forth the matter as it is: for I would by no means enter into diſputes about words, but would give each its natural ſignification, provided the eggs, as they are called, be referred to the fourth order of diſagreeing tranſmutations, which is the moſt worthy of notice in all nature; for in this proper diſtribution of things conſiſts the great utility of the preſent work.

In proceeding to elucidate this obſcure order of changes ſomewhat more, I muſt repeat, that theſe Worms, which undergo this particular change, do not put off, but abſolutely retain, their skin, under which their limbs are inſenſibly increaſed and brought to perfection; and therefore, if that skin be tender, it accommodates and contracts itſelf to the figure of the encloſed Nymph. For the ſame reaſon alſo, as the old skin is preſerved, the original rings, which, like ſo many ſmall joints, divide the body of the Worm, may be then ſtill ſeen therein; though, in the mean time, theſe inciſions or rings, in ſome caſes, appear to be obliterated, or nearly ſo, in the skin. This holds chiefly, when the inciſions either have not been very diſtinct in the Worm itſelf, or when a very thin skin, every where entirely obedient to the inwardly hidden Nymph, is ſo extended therewith, that the inciſions or inflexions of the body cannot be any longer known. This I have exemplified in Tab. XLV. Fig. XXVII. and XXVIII.

I have obſerved alſo, that the skin, which is not caſt off, in ſome of theſe eggs, as they are called, has been ſo accurately fitted and accommodated, all about the body of the Nymphs contained within, that it diſtinctly and externally repreſented the three principal diviſions of the body; that is, the head, thorax, and belly. And hence it is, that ſome of theſe Nymphs are obſerved to be, as it were, annulated; and others are without rings. This has likewiſe been partly obſerved by the before celebrated ſagacious gentleman. Thus I have briefly explained all thoſe things which I thought neceſſary to be taken notice of, before I undertook to define this fourth order.

I now therefore proceed, and ſhall direct all my labour to make manifeſt, as clearly as I can, the ſtupendous works of the moſt adored and all-wiſe Creator, which have been hitherto, to our ſhame, but little known; that we may therefore love God, our Creator, with the greater and more ardent zeal, and behold him with higher veneration. We can neither juſtly love or reverence God, ſo long as we are darkened with our ignorance. Let us, therefore, give praiſe and thanks to the Supreme Architect for his unmerited favour, ſince he alone has lighted, and laid before us, the cleareſt fire in all nature: a light, which has not only eaſily diſcovered his moſt wiſe providence and infinite power, in thoſe wonderful means which he makes uſe of to defend and preſerve thoſe things which he created; but has alſo produced thoſe things ſo openly to the view of all men, that its ſplendour cannot be obſcured by any laboured arguments of human origin. We thus ſee, indeed, no more than the ſurface, or, as it were, the ſhadow of the wonderful works of God delineated here, or by any other. And this ought, indeed, to be the greateſt encouragement to us, that we may indefatigably exert ourſelves in theſe reſearches, and rather ſeek for the cauſes and effects of things in nature herſelf than in our ſtudies. Indeed, moſt people are at this time ſo blind, that they imagine no truth ariſes from any other ſource than out of their reaſonings; to which they contend, place ſhould be given as to matters which ſurpaſs even nature. Indeed, we cannot know natural things but by their effects, being incapable of comprehending their cauſes.

Let us return now to what we propoſed; and let it be obſerved, that our fourth order of changes conſiſts only in this, that the Worm, having quitted its firſt form, which it had in its egg, wherein it lay, like a Nymph, without food, inſenſibly acquires, by force of the aliment it is afterwards ſupplied with, other limbs and parts, ariſing by accretion under its skin; and afterwards, at length, in this its skin, which is never caſt off by it, as it is by other creatures that are changed into Nymphs, it aſſumes the form of a ſecond Nymph, and for the firſt time loſes, as it were, all its motion. This, however, is in a few days reſtored to it, by the evaporation of the ſuperfluous humours: ſo that the Worm, then laſtly diſengaging itſelf from theſe skins, caſt two skins together; and now diſplaying itſelf with pride, in a more elegant garb, and become mature, as it were, for propagation, it immediately ſhews itſelf ready to perform this, the great buſineſs of its life.

A catalogue of the inſects referred to the fourth order or claſs of natural changes, which we call the Vermiform Nymph.

AFTER having ſet forth, with all the perſpicuity and diſtinction I have been able, the four orders of changes which I have eſtabliſhed, and before enumerated the inſects of the ſecond and third order, I now proceed to recount thoſe creatures which I obſerve to belong to the fourth. A great number of theſe I have preſerved in my Muſeum.

Firſt, I refer to this fourth order the eggs of inſects in general: not only thoſe, which produce a perfect creature according to the firſt order, and thoſe which, in the ſecond order, contain a Worm; but alſo thoſe which, in the third and fourth orders, produce a Worm or Caterpillar. For I obſerve, that all theſe creatures and the Worms are diſpoſed in their eggs and skins, nearly in the ſame manner as I have ſaid the Nymph of the fourth order, a little before deſcribed, is in its uncaſt skin. Even thoſe little creatures, which iſſue perfect or imperfect out of their eggs or ſhells, caſt two skins at the ſame time: and this has appeared to me very evidently in ſome; nay, I can ſeparate even the external from the internal in ſome of them, as I ſhall ſhew hereafter in my figures. From this the reaſon is evident, why I ſay that theſe inſects lie in their eggs like Nymphs, and are as much removed from our view as the Nymphs of our fourth order, juſt now deſcribed; that is, as I have already obſerved, the external skin, in each caſe, prevents the Nymph from being ſeen and known.

Of thoſe eggs, which, in my firſt order or claſs of changes, I called Oviform-Nymph-Animals, and, in the ſecond, third, and fourth orders, Oviform-Nymph Vermicles; I preſerve a great many ſpecies, vaſtly different from each other, not only in ſhape, ſize, and colour, but in their origin likewiſe, being, as I have already obſerved, the produce of different inſects. Particularly, there are in my collection ſome very minute Flies, immediately ſprung from the eggs, which the Moths faſten with a kind of glue round the branches of trees, in form of a ring. Hence it plainly appears, that the eggs of ſuch inſects belong to the firſt mode or method of the fourth order.

Having ſaid thus much of eggs in general, I now, in the ſecond place, and in a more particular manner, refer the Worms found in our privies, or neceſſary-houſes, to the ſame order, and the ſame mode of change, as, on their alteration to Vermiform-Nymphs, they loſe nothing of their original ſhape; but are only covered with a hard and ſtubborn skin. I can produce that ſpecies of thoſe Worms, and of their Vermiform-Nymphs, from which the common Flies of neceſſary-houſes proceed; and have therefore given, in the XXXVIIIth Table, drawings of this inſect in the Worm, Nymph, and Fly-ſtate, beſides one of its eggs, which are very remarkable, drawn from a ſpecimen I keep amongſt my other curioſities of this kind.

Thirdly, I place in this order the Vermiform-Nymph of the Gadfly, as it perfectly retains the form it wore in the Worm-ſtate. The XXXIXth, XLth, XLIſt, and XLIId Tables, with their explanations, give a ſatisfactory account of every thing for which this inſect is particularly remarkable, in diſpoſition, ſhape, and changes from a Worm to a Fly; including the figures of the apparent Nymph, and that of the real Nymph, which the apparent Nymph includes. This Fly, as Ariſtotle rightly obſerves, proceeds from a kind of broad and flat water Worm; the ſame with thoſe inſects which Aldrovandus, without knowing that they produced the Gadfly, has deſcribed by the name of Water-worms, or Inteſtines. I preſerve four ſpecies of this Worm, with the Flies to which they change; as likewiſe an apparent Vermiform, or worm-like Nymph, of a very ſingular ſhape, and the real Nymph, extracted by diſſection from the inſect in that motionleſs condition. I have frequently met with this kind of Fly, about the end of ſummer, in the flowers of the garden-parſnep; though, at the time when I formerly made my ſelect obſervations, I could not diſcover what their food was.

I likewiſe reckon of this order the Vermiform, or worm-like Nymph of the Tabanus, or Breezefly; though I am, as yet, at a loſs for its * origin: but I have great reaſon to believe, that the manner of its becoming a Fly is the ſame with that of the Aſilus, or Gadfly. It is very remarkable, that nature has given theſe inſects an aculeus, or ſting, as well as a trunk; ſo that they may either make uſe of the trunk to procure the honey, dew, and other juices which ſpontaneouſly offer themſelves upon plants and flowers; or of the aculeus, or ſting, to ſuck blood of ſuch creatures as they are obliged to kill or wound to feed upon. How admirable the mercy of their Great Parent, in having ſupplied them with this double reſource in their neceſſities! Gnats ſeem to partake alſo of this advantage; but as to other inſects, which feed upon blood, ſuch as Bugs and Fleas, I muſt refer, for the ſhifts they can make, to future experiments. Another thing remarkable in theſe inſects is, that the honey-juices they ſuck up with the proboſcis, or trunk, are always accompanied by a quantity of air, which may be very eaſily ſeen, eſpecially in the trunk of the Butterfly.

* The origin of this Fly is, indeed, very ſtrange. The parent lays its egg in the fundament of a horſe, watching the opportunity of the creature's voiding its excrements for this purpoſe. From this egg are produced the Worms which farriers call Bots, in the inteſtines of horſes. Having lived their time in the creature, they are voided with its dung, and take their chance for paſſing the Nymph-ſtate upon or juſt under the ſurface of the ground; after which they appear Flies, like the parent.

In this order alſo I rank the Horſe fly, particularly ſo called, of which I have, as I think, ſeveral different ſpecies. I cannot indeed poſſitively affirm, thas they all properly belong to it; for to do that, I ſhould have many more obſervations, which I muſt leave to be made by others that can take due pains, and have more liefure.

Fourthly, I place in this order the Vermi-form Nymph of the ſtingleſs Bee, or Muſca-ſtercorariae, or Dung fly, of Goedaert; tho' it agrees with the laſt mode or method of this order; for its Worm has a much more delicate skin, than the Worms hitherto taken notice of as belonging to the former mode; ſo that its Vermi-form, or Worm-like Nymph, differs greatly in ſome parts from the form of the Worm in which it before appeared. This Worm is beſt diſtinguiſhed by the extraordinary length of its tail. It is produced from eggs which the Fly, to which it turns, depoſites alſo in neceſſary houſes. Amongſt the Flies to be ſeen in ſuch places, ſpecimens of which I preſerve in my Muſæum, there is one of which I have now been ſpeaking, with feet, horns, and tail, and likewiſe its Vermi-form Nymph with the ſame parts. All theſe little creatures are ſeparately exhibited in Tab. XXXVIII.

Fifthly, I refer to this order the Vermi-form nymph of the Acarus, which exhibits, though ſomewhat obſcurely, the ſhape of its Worm; for as its skin is very tender, it contracts itſelf ſo as to appear externally of an oblong round figure like an egg. I can oblige the curious with a view of this Worm's Nymph, the skin it caſts, and the Fly it produces; and for the preſent, they may amuſe themſelves with Tab. XLIII. where theſe curioſities are all repreſented as big as, and alſo bigger than the life, and with the ſeparate deſcriptions that I have given of them. One thing very remarkable in theſe Flies is, that in its act of copulation, the penis of the male receives into its cavity the vulva of the female.

Sixthly, I count of this order the Vermi-form Nymph, of a certain greeniſh Worm without legs, that lives upon the leaves of cabbage, and of which I intend to give a hiſtory in its proper place. In the mean time, I preſent the readers with figures of the Worm itſelf, its true Nymph, and the Fly iſſuing from it, in Tab. XLV. Fig. XXVI. and following figures. This Worm in the Nymph-ſtate loſes more of its form than the Acarus, as it has a more delicate ſkin; but this particular will hereafter be taken notice of in the hiſtory of the inſect.

Seventhly, I give in this order, which I have eſtabliſhed, all thoſe Vermi-form Nymphs, or, as ſome call them, eggs of Worms, which are nothing but the Worms themſelves contracted into the form of an egg, and are very prepoſterouſly thought to proceed from putrified animal ſubſtances. Such Worms, after loſing all motion, change to true Nymphs within their external skin; and ſo reſemble Vermiform Nymphs; from which in a few days, there proceed a great number of different kinds of flies. Nor do theſe flies differ only from each other, but likewiſe the Worms, from which they originally, and the Vermi-form Nymphs from which they immediately proceed, have the ſame variations; for ſome of theſe Nymphs are in appearance more like eggs than others, in proportion to the delicacy of the Worm's ſkin which produces them, or to the reſemblance which the Worm itſelf has to an egg.

All thoſe Worms void their excrements on the fleſh upon which they feed, which not only makes ſuch fleſh putrify, and ſtink the ſooner, but increaſes its natural ſtench and putrifaction. Redi has deſcribed many ſpecies of thoſe Vermi-form Nymphs; but he calls them all eggs, without making the leaſt mention of their being the real Nymphs of Worms, changed to that ſtate, without caſting their external ſkin. However, we muſt allow him the honour of having proved, by the moſt ſolid arguments, that theſe Nymphs, or eggs, as he calls them, are not generated of putrifaction.

Eighthly, I innclude, in this fourth order, all theſe Worm-like, or, as they are called egg-like Nymphs, produced from contracted Worms, which we know, by obſervation, conceal themſelves in the bodies of living Caterpillars, out of which they again eat their way. Theſe Worms then loſe all motion without caſting their external ſkins, ſo as to aſſume the appearance of Vermi-form or Worm-like Nymphs; and, in a few days more, they turn to many very different ſpecies of Flies. I muſt own it an error, to give the epithet of Oviform or egg-ſhaped to every kind of Nymph produced in this way; for, there is, on the contrary, ſo great a variety in their forms, that it would be the buſineſs of an entire treatiſe, to give ſeparate deſcriptions and figures of them all.

I do not find that theſe Worms void any excrements, after quitting the bodies of the Caterpillars upon which they feed; they immediately contract themſelves, and become motionleſs within their external ſkin, till at laſt they are thus under its coverture changed into true Nymphs, in every reſpect like thoſe already deſcribed, as belonging to the firſt ſpecies or method of the third order. This kind of mutation in inſects, performed by their contracting themſelves into the Nymph-form, after gnawing a paſſage out of the bodies of Caterpillars, into which they had inſinuated themſelves, has not as yet, as I know of, been obſerved by any writer.

I have alſo remarked, that theſe Worms have ſometimes remained in the hollow of the Caterpillar's body, after they had entirely devoured its fleſh, and thus turned to Flies, after paſſing thro' the Nymph-ſtate; ſo that, in order to appear, they muſt have forced a paſſage through three different ſkins, namely the membranaceous ſkin immediately covering the Nymph, the external ſkin of the Worm from which they originally proceeded; and laſtly, the ſkin of the Caterpillar, whoſe carcaſs they had preyed upon.

For want of ſufficient experiments in an affair that would require a great many, I cannot as yet take upon me to determine, how the Worms, of which I have been ſpeaking, come to be found in the bodies of Caterpillars; whether it be that they are introduced into them in the

the form of eggs, or whether they proceed from them as from an internal principle? A great deal may be ſaid in favour of either ſyſtem; it is therefore neceſſary, that I ſhould defer, for ſome time, the diſcuſſion of this important queſtion, as I cannot yet produce any ocular demonſtration to ſupport either opinions. Nevertheleſs, I muſt obſerve to ſuch as are fond of natural hiſtory, that it is impoſſible for them to gain a competent knowledge of the diſpoſitions and changes of Caterpillars, without feeding on purpoſe a great number of thoſe inſects of the ſame ſpecies, in order to have an opportunity of tracing them through all their changes: nor will this care alone be ſufficient, for nothing but repeated diſſections can give any ſatisfactory idea of their internal parts. The naturaliſt, who ſhould think of ſucceeding in any other manner, would loſe his pains, and remain in perpetual ignorance.

Ninthly, I reckon, among the creatures of my fourth order, thoſe Vermi-form Nymphs, or, as they are otherwiſe called Eggs of Worms, which are produced by thoſe contracted Worms, which, it is pretended, iſſue from the putrified bodies of Aureliæ. We ſee great numbers of different kinds of Flies, iſſuing from ſuch Worms, in a few days after they become motionleſs, within their ſkins, and thereby aſſume the appearance of theſe Vermi-form nymphs we have been diſſecting. Mouffet was the firſt who took notice of theſe kinds of mutation. After him Goadaert treated of them; and ſince him Redi, and many other authors. I have given by itſelf, Tab. XXXVIII. Fig. x. a drawing of one of theſe Worms, and likewiſe of one of the Vermi-form Nymphs, whoſe reſemblance to an egg is merely ſuperficial.

I place alſo in this my fourth order, the Vermiform Nymphs proceeding from Worms, which, contracting themſelves within the bodies of Aureliæ, without caſting their external ſkin, thus acquire the ſhape of an egg; this is a thing which I very ſeldom have had an opportunity of ſeeing; for theſe Worms generally open themſelves a paſſage out of the Aurelia, as ſoon as they have acquired their full growth, as I have ſhewn already. There is ſufficient reaſon why they ſhould do this. The Chryſallides are generally ſomewhat moiſt, which makes it neceſſary for the Worms contained in them, to leave their bodies, and find out a more convenient ſituation for their external ſkin to harden, in order to their becoming Nymphs. But whenever it happens, that when all the moiſture of the Chryſalis is exhauſted by theſe Worms as their food, ſo as to permit the ſkin of the Chryſalis itſelf to harden and grow dry, then the encloſed Worms remain within it till they become Nymphs, and from Nymphs, Flies, to appear abroad; in which form they muſt alſo make their way through three different ſkins, as well as the Flies generated in the bodies of Caterpillars, whoſe labours on the like occaſion, have already been taken notice of.

All thoſe Nymphs of our fourth order, hitherto taken notice of, change in the end to different kinds of Flies, as has been already obſerved, and I preſerve a great variety of the Flies produced from them, among my other natural curioſities.

Having thus enumerated the inſects that properly belong to my fourth order, I ſhall finally add to it all the Nymphs of thoſe Worms of the firſt, ſecond, third, and fourth orders, which are changed into the ſaid form of Nymphs, within the bodies or ſkins of other Worms, of Caterpillars, Nymphs, or Chryſallides, as likewiſe thoſe changed within the ſeveral excreſcences of trees and their leaves, in form of warts, galls, and the like. However, I muſt obſerve, that I do not rank ſuch Nymphs in the fourth order, as having any further right to it, than that of becoming Nymphs, like the Worms which really belong to it, in an obſcure, hidden, and myſterious manner. A perſon muſt have great experience in theſe little creatures, to be able to ſpeak of them with certainty in their whole hiſtory.

In the eleventh place, I likewiſe reckon of this order, all thoſe genuine Nymphs which are to be found within the body or ſkin of any Worm or Caterpillar, and are the offspring of Worms, which have preyed upon the fleſh of that Worm or Caterpillar in which they are found. Thus it now and then happens, that a Worm or Caterpillar, not having ſtrength enough to caſt its ſkin, becomes hard and firm, without loſing any thing of its external form; in which caſe, the worms that have hid themſelves in it, devour all its fleſh, and being freed in this manner from any neceſſity of altering their ſituation, they change there to genuine Nymphs, and afterwards to Flies. Sometimes a ſingle Worm of an extraordinary ſize poſſeſſes himſelf in this manner, of the whole body of another larger Worm, and without ever leaving it, becomes therein a Nymph, and afterwards a Fly. But if the Caterpillar ſhould retain vigour enough, notwithſtanding ſuch cruel treatment, to throw off its external ſkin, and reach the ſtate of a Chryſalis, then the body of ſuch Chryſalis becomes the ſcene of all the foregoing mutations.

What ought to be conſidered as a greater paradox than all, is, that theſe Worms ſometimes deſert the body or ſkin of the Caterpillar, upon which they had hitherto preyed, and upon deſerting it, encloſe themſelves in an oviform web, within which, they at length change to real Nymphs, and afterwards into Flies. I ſhall have an opportunity of treating this ſubject more at large, when, if it pleaſe God, I come to publiſh my ſelect obſervations; ſo that at preſent, I do not pretend to treat of this change in a particular manner.

Twelfthly, I refer to this fourth order thoſe genuine Nymphs, which become ſuch from Worms, within the ſkins or bodies of Chryſallides, in the ſame manner with the Worms of our third order, and firſt method; but I mean only ſuch Nymphs as are found ſingle in the Chryſallides corroded by them.

I have obſerved, that thoſe Nymphs are of many and various kinds, and indeed ſo different one from another, that it would be a difficult taſk to deſcribe them ſo as to be diſtinguiſhed each from the reſt, without the help of particular figures. There is one thing remarkable in ſuch Nymphs, which is, that we may eaſily obtain a full and ſatisfactory view of their change from the Worm to this ſtate, and of the admirable order obſerved by nature, in affecting this tranſmutation, ſo as to trace with our eyes the mutation hitherto conſidered as a metamorphoſis of the creature, from a Worm to a flying Inſect.

I cannot therefore ſufficiently wonder, that none of the authors, whoſe works I have read, have taken any notice of the Worms now under our conſideration, or given us any drawings of the Nymphs of ſuch Worms. Goedaert, it is true, was acquainted with the Flies, to which they at laſt change, and has given us pretty good figures of them. To deſcribe theſe Flies in a few words, I need only remark, that I have already taken ſufficient notice of them under the name of the Pſeudo-ſphecæ in the detail of my third order, to which they properly belong: in that place too, I obſerved, that Goedaert's devourer or deſtroyer of Spiders, ſhould be looked upon as a Fly of the ſame tribe.

I ſhall now deliver the method of viewing theſe moſt ſingular and intereſting changes. Care muſt be taken to obſerve when the Chryſallides harden, and change colour; juſt at that time they are to be broke open, and the encloſed Worm taken out, and put into a little box, where you may very diſtinctly and conſpicuouſly behold its gradual change to a Nymph, and from a Nymph to a Fly. I ſhall, at another time, with God's permiſſion, and with a view of promoting the glory of the wiſe and powerful Creator, endeavour to ſet in the cleareſt light, among my ſelect obſervations, the manner of ſuch mutation; and likewiſe to ſhew what a great quantity of excrements this Worm voids in the mean while; and how it ſometimes is obliged to ſpin a web, with many other particulars very well worth the attention of the curious. At preſent, I have not oppportunity to dwell any longer upon this ſubject.

In the thirteenth place, I count of this order thoſe Nymphs which become ſuch, and afterwards Flies, from fifty to two hundred together, in the ſame manner with the Nymphs laſt mentioned, within the body, or ſkin of a ſingle Chryſalis, and proceed originally from a great number of little Worms that have preyed upon this Chryſalis. Theſe Flies alſo were known to Goedaert, though he was altogether ignorant of the true manner of their generation, or the real nature of the Nymph, by which alone theſe hitherto ſo perplexing appearances can be ſolved. Nor ſhould I have ſucceeded any better than thoſe who have gone before me in this province of Natural Hiſtory, had I not, purſuant to the advice of the immortal Harvey, called anatomy to my aſſiſtance, upon every occaſion, and laboured with inſuperable patience to diſcover, and diſtinctly comprehend, the true principles of thoſe ſurpriſing changes, as often as there was a poſſibility of diſcovering and comprehending them. Without experiments, we cannot expect any clear and certain knowledge in matters of this kind, whether our concluſions are drawn immediately from our own reaſonings concerning the things before us, or from inductions built upon their reſemblance to others, we are equally liable to go aſtray, and miſtake the productions of our own imagination for the repreſentations of nature, as ſubſequent experiments generally prove. Deſcartes therefore had great reaſon to ſay, that he ſet more value upon the ſolid experiments of mechanicks, than the barren and fine-ſpun contemplations of philoſophers. The creatures juſt taken notice of, as appearing in great numbers within the ſkin or body of a ſingle Chryſalis, may be traced through all their mutations, in the ſame manner with thoſe that require each of them an intire Chryſalis for this purpoſe; and certainly a favourable opportunity of viewing, though but once, ſo great a miracle in the works of nature, muſt afford the higheſt pleaſure to thoſe who are deſirous of being acquainted with ſuch wonders: but now they may eaſily procure themſelves this ſatisfaction, as I have, I flatter myſelf, removed, though not without great pains, the many obſtacles which hitherto oppoſed their deſires.

I place alſo in the fourth order, thoſe genuine Nymphs, which become ſuch from Worms of a particular kind, found within the bodies of larger Vermiform Nymphs, in the ſame manner with the Worms of the firſt mode of the third order. This I had an opportunity of obſerving in the Vermiform Nymph of the common Fly of our neceſſary-houſes; and the ſame is to be obſerved alſo in the inſects of the firſt order.

In the fourteenth place, I muſt add alſo to this order, all thoſe genuine Nymphs which we find in the middle of fruit, in the warts of ſhrubs *, and the leaves of plants, in rotten parts of wood, and in other obſcure and ſecret places. I have collected ſome of theſe Nymphs, and the Flies into which they change; as alſo the ſeveral ſubſtances in which the worms are found; all which the curious are welcome to examine, that the adorable Author of ſuch wonders may receive an additional tribute of praiſe and glory. I preſerve likewiſe ſome of thoſe Flies which proceed from the little Worm, that Redi found within the excreſcencies of willows, without being ever able to diſcover their changes. On opening the bodies of theſe Flies, we meet with eggs, which perfectly reſemble thoſe found in the ſame excreſcences; from whence, as well as from many other obſervations, we may fairly conclude, that all the Worms found in vegetable ſubſtances, are originally depoſited there by the parent inſects in the form of eggs. For a particular illuſtration of theſe things, I muſt refer to the explanations of the XLIV. and XLV. Tables.

* Theſe all owe their origin to eggs of Flies, and principally to the ſeveral ſpecies of Ichneumon-fly, which this author calls Pſeudo-ſphecæ. All inſects are directed by inſtinct to depoſit their eggs where the young will find food. Butterflies do this on the ſurfaces of leaves. Theſe Flies lodge them in the ſubſtance. They have for this purpoſe a hard and ſharp inſtrument at the hinder part of the body, and with this they bore a hole in the leaf or rind, and lay their eggs. The wound and juices thrown into it by the animal, alter the courſe of the fibres, and hence ariſe galls on the oak; in each of which, there always is a worm originally, the burrs upon the Dogroſe, and innumerable other vegetable excreſcences.

In the fifteenth place, I muſt infert in this order, all thoſe inſects that change, as it were, into a kind of web. To this claſs or order, more particularly belong thoſe little Worms, whoſe web is ſo fine, tender, and delicate, that a perſon muſt have great practice in things of this kind, to open it without breaking. Within this web, the Worms change to very ſmall Nymphs. I therefore refer to this order Goedaert's Flies, produced from the genuine Nymphs of Worms, which the ſaid author tells us in his XIth Experiment, Part I. crept out of the body of a Caterpillar that fed upon cabbages, and then made themſelves each a neſt of a yellow ſilk, in which they afterwards ſhut themſelves up. But Goedaert knew nothing of the Nymphs of thoſe Worms, as appears by all that he ſays in the place already cited. Nor was accurate Mr. Ray, Catalog. Plant. page 137, already mentioned, happier upon this occaſion than Goedaert, whoſe obſervations he was acquainted with. This gentleman imagined, that the Worms here ſpoken of, lay hid within their webs in the form of Worms: he even went further, and committed another miſtake, in thinking that the eggs of theſe inſects, diſtinguiſhed by annular inciſions, were real Nymphs, and not their oblong tranſparent eggs: for thoſe alone are Vermiform-Nymphs, though both in reality certain genuine Nymphs not as yet viſible. I have ſometimes alſo obſerved Worms, which form for themſelves under ground an oviform caſe or ſheath, which a perſon, not acquainted with things of this nature, might eaſily miſtake for a Vermiform-Nymph.

Moreover, I give a place in this order to ſuch Nymphs of Worms or Caterpillars, as are found upon the leaves of willows, encloſed in a very fine and delicate covering, or web of the ſame kind. Theſe Nymphs are changed in time to a very delicate Fly, which the curious may ſee together, with its web or covering, among my other curioſities.

Laſtly, I refer to this order the genuine Nymphs of a kind of Worms, which having made their way through the Caterpillar's ſkin, upon the fleſh of which they had fed, not only ſpin themſelves a covering of white ſilk, but fortify it with a kind of cottony ſubſtance, which the parent Caterpillar had formed for its own uſe; and in a few days after this operation, force a paſſage through both theſe encloſures in the form of Flies. I preſerve in my collection almoſt all the different kinds of Flies hitherto mentioned, with their coverings or webs, ſo that I can give, in a manner, an occular demonſtration to thoſe who deſire it, of every thing that I have advanced concerning them. I have, beſides theſe, many other kinds of webs, which my deſire of making a ſpeedy end of this ſubject, hinders me from enumerating at preſent.

I may include, in this order, in the ſixteenth place, all the genuine Nymphs which have ariſen from Worms, which undergo their changes within very ſlender and delicate habitations of their own forming, and which they conſtantly carry about them, as ſnails do their ſhells, till at laſt they change to Flies, and again betake themſelves to the open air. I preſerve, in my Muſeum, a great variety of ſuch Flies, and their Nymphs and Worms, together with the ſurpriſing caſes of the latter, in which they lie hid, and wherein they walk about with, ſome in the earth, and ſome in the water. Some of theſe Worms are mentioned by Aldrovandus, who deſcribes them by the name of Xylophthori, or Worms that deſtroy timber. I have likewiſe ſome Flies which are produced from theſe Worms, a few of which have been already deſcribed under the name of Ephemeri. Laſtly, it muſt be remarked here, that all the Nymphs of the fourth order, may truly be reckoned of the third, if we conſider them in themſelves alone, and without paying regard to their ſkins, which they do not caſt, or the webs and hidden caſes, in which they conceal themſelves.

Thus I ſhall finiſh this enumeration, and general deſcription of the inſects of the fourth order, which I ſhall hereafter more particularly treat of, and illuſtrate by juſt and careful hiſtories, and convincing examples.

A ſingular example of the fourth order of mutations, exhibited in a Fly; whoſe metamorphoſis, or natural accretion into the firſt form of its limbs, and other parts, I call a Vermiform-Nymph.

TAB. XXXVIII.

N°. I. THE Worm of the common Fly of our privies or boghouſes, repreſented of its natural ſize, and as it appears under its firſt coat or ſkin, in which form it is called an egg. This firſt figure exhibits the egg, as viewed with the aſſiſtance of the microſcope.

N°. II. The double coat or ſkin of the egg, which ſkin or coat the Worm leaves behind it, when it is hatched; or, in other words, creeps out of it. This coat is repreſented as magnified by the microſcope, to twice its natural ſize.

N°. III. The Worm itſelf, ſomewhat bigger than it really is, when it has juſt crawled out of the membrane, in which it was concealed under the form and name of an egg.

N°. IV. The ſame Worm, arrived at its full growth, and crawling about. As the feet of this Worm are very ſhort, and narrow withal, it always moves, and, as it were, draws itſelf forward by the help of its head or beak: therefore, if you put it on a ſmooth piece of glaſs, it walks with great difficulty; whereas, upon a coarſe cloth, it will advance pretty briſkly; for it thruſts its head into the little hollows and cavities of the cloth, and very nimbly draws

up

up to the head, where thus anchored as it were, the reft of its body, which has only very fhort feet about the hinder part of the belly. In this refpect, therefore, the Worm, of which I am fpeaking, agrees very remarkably with the water Worm, from which the Afilus or Gadfly proceeds. The Worm of that Fly carries its feet, as it were, in its mouth; but I cannot pretend to fay the fame thing of the boghoufe Worm, as I have not as yet examined it fufficiently; though I think it very probable, that its principal feet are fituated in that part. The third figure exhibits this Worm increafed by the microfcope, to a confiderable magnitude.

N°. V. I exhibit in this place the Worm already reprefented under the form it has, after lofing all motion, without cafting its fkin; within which, notwithftanding, it becomes a genuine Nymph: and its becoming a Nymph, in this manner, muft, I think, be looked upon as a fufficient reafon for my giving it this new name of the Vermiform-Nymph, fince, at the fame time that it retains the appearance of a Worm, it really changes, under fuch appearance, to a genuine Nymph. This fpecies of Nymph, with the Worm's fkin upon it, in the fourth figure, as it appears when magnified by a microfcope, and the Nymph itfelf ftripped of its fkin, is exhibited in the fifth figure, fomewhat larger alfo than nature: but the fixth and feventh figures, next following, reprefent it magnified to much larger dimenfions.

N°. VI. Exhibits the boghoufe Fly in its perfect ftate, as it appears when it has caft its two fkins together; namely, the external hard fkin, in which it had the fhape of a Worm, and under which it continued when changed to a Nymph; and the internal and more delicate skin, proper to it as a Nymph; for this infect throws off both thefe skins at the fame time. We may obferve here, with what extraordinary elegance it is cloathed, when the time is come for it to appear abroad, and attend to the great work of propagating its fpecies! The eighth figure exhibits the Fly, as it appears when greatly magnified by the microfcope. I fhall hereafter explain this figure at large, when I come to defcribe the infect's external ornaments. There is, it appears, a remarkable difference between this order of changes and the firft; as, in the firft, the creature iffues perfect from its egg, without paffing through any intermediate ftate. This order differs alfo from the fecond, as the infects of that order acquire certain membranaceous cafes or coverings of the parts within, which rife above the reft of the furface of their bodies. And, finally, it differs from the third order, in which the creatures caft, at different times, the skins wherein they appear as Caterpillars, and the covering they afterwards wear in the form of Nymphs; for, in the fourth order, both thefe coats come off together. On the other hand, the infects of all thefe orders have thus much in common: they are Nymphs under all thefe ftates, and in every order; and they fo long and fo often change their skins, till they are become perfect and ready for the work of generation. The Nymph, therefore, having its place in all the four orders, is the true, the only, and immutable foundation, upon which the changes of all thefe infects depend, as I have attentively and at large demonftrated in the beginning of this work. I make only a curfory mention of it in this place, the better to fix fo important a truth in the memory of my readers.

TAB. XXXVIII. FIG. I.

By this figure, which reprefents the boghoufe Fly's egg bigger than nature, we obferve that it is of an oblong and angular conftruction, fo as to form, in a manner, an elegant, chequered, and reticulated reprefentation of that kind of cake known in Holland by the name of Woffel. Thefe eggs are of a delicate whitenefs, and they have two integuments, which are eafily diftinguifhed one from the other. The outer integument is the real fhell; and this is, in every refpect, like the fhell of a hen's egg, as appears by its breaking to fmall pieces in the fingers. By this means it is an eafy matter to feparate this outer cruft from the internal covering, which properly contains the embryo of the boghoufe Worm. As thefe eggs are moift when juft laid, and are depofited by the parent Fly upon the walls of boghoufes, and fometimes even in the skins fhed by former Nymphs, they ftick together, when the air has dried the intervening humidity; fo that, on endeavouring afterwards to feparate them, part of the external fhell of one egg comes off, with the inner fubftance fticking to it. By this means the angular form of the latter acquires a kind of projecting border. This was the cafe with the egg here reprefented, which I thought proper to exhibit in that form, in which alone I could procure it fingle, on account of its firm cohefion with the adjacent eggs.

FIG. II.

I here reprefent the delicate internal membrane which covers the egg, as it appears about the fore-end of it. This membrane has been broken by the boghoufe Worm, when it crept out of the egg; fo that we may fee in what manner the external cruft or fhell has been cracked upon this occafion, and how it has crumbled off from the internal membranes. It is very furprifing how thefe eggs are covered with fo hard a fubftance, refembling plaifter of Paris; though it feems probable that Nature ordained it fo, the better to fhelter the enclofed embryo Worm from the putrid and fharp effluvia arifing from boghoufes, in which places it is often depofited. This led me to an experiment, by which I have found, that the faline acrimony of urine makes no impreffion upon thefe eggs. But it is not in boghoufes alone thefe eggs are to be found: we meet with them in feveral other places, particularly where fruits, herbs, and other fucculent vegetables, lie and rot. But they appear no where fo beautifully, or or to ſuch advantage, as in the Oviducts of the female Fly, opened for this purpoſe; and, no doubt, the moſt certain method of inveſtigating the eggs of inſects, ſo as to obtain ſome certain knowledge concerning them, is that by diſſection of the inſects; but then the opening of theſe ſmall animals at the exact time, when their eggs are perfect in the Ovary, and ready for laying, depends entirely upon chance.

I have a ſmall box full of inſect's eggs in my collection, ſo very curious, that I ſhould not think a particular treatiſe ill beſtowed upon them; for they all greatly differ from one another in ſhape and colour. Some are oblong, others oval; ſome again perfectly round, others angular; ſome pear-ſhaped, ſome like the ſeed of the carduus benedictus, and others of other forms. There is alſo the greateſt variety of colours amongſt them; white, yellow, red, ſky-coloured, green; and in ſome is to be ſeen a beautiful mixture of ſeveral colours, ſo as to make it almoſt impoſſible to give a particular account of them. Some alſo are ſoft, others hard; ſome are only covered with a ſlight membrane, whilſt others have a ſhell, or firm cruſt, like parchment. Again, ſome are ſheltered by a froth that ſurrounds them, others are covered with hair: ſome are found faſtened by a viſcous matter to the branches of trees, ſo as to form a ring about them; others lie ſingly, and at random. Some ſtand cloſe to each other upon their ends; others lie parallel to the horizon; and ſome are found buried in animal and vegetable ſubſtances, whilſt others are only laid in a looſe manner upon the ſurfaces of ſuch things.

FIG. III.

I here lay before the reader a figure of a Worm, which changes to the boghouſe Fly, as it appears when magnified by the microſcope. We may clearly diſcern in it thoſe annular diviſions, of which ſome conſtitute its head, the next to them the thorax, and the hindmoſt the creature's abdomen and tail. The circumference of every part of the body appears adorned with ſeveral, as it were, prominent feathered bandages. But the inſect loſes the advantages of theſe as ornaments, becauſe it cannot but foul them, by crawling through the offenſive matter upon which it feeds. For this reaſon it ought to be well waſhed, in order to become fit for a microſcopical obſervation: nor need we fear to do it any injury, by treating it in this manner; for it has a ſtrong conſtitution. Beſides, this Worm is one of the ſpecies of inſects which have a hard ſkin, the better to reſiſt the acrimony of the putreſcent juices, amongſt which it lives. This hardneſs of the boghouſe Worm's ſkin, is the cauſe of its not loſing its external form, when it changes to a Nymph.

FIG. IV.

It muſt be here very thoroughly conſidered, that theſe Worms, on their aſſuming the ſhape of Vermiform-Nymphs, become motionleſs, and ſoon after draw up their ſnout within the head; by which, and by a contraction of all the rings of their body towards each other, they become ſhorter, in ſo conſiderable a degree, as may be ſeen in the fourth figure now before us: which likewiſe ſhews, that there is but little difference between the Worm repreſented in the third figure, and the Vermiform-Nymph exhibited in this place. The only difference is this, that the Nymph is without any motion, whereas the Worm moves itſelf very briſkly. The drawing in of the ſnout in the Nymph, ſcarce makes any difference; for the Worm itſelf is very often obſerved to do the ſame thing. But we muſt here take ſpecial notice, that all the Worms of this fourth order are not all changed to Nymphs, in the ſame manner with the ſpecimen of that order, which I here explain: neither do all the Nymphs equally exhibit the former limbs of their reſpective Worms; the only reaſon of which diverſity I take to be this, that ſome of theſe Worms have a more delicate ſkin than others, and conſequently it is better adapted to conform itſelf to the ſhape of the latent Nymph, when the inſects change into that condition. This I ſhall demonſtrate in the ninth and tenth figures, by two particular and very evident examples, which will ſupply us with a rule to judge by, in every caſe of the like nature.

There is one circumſtance more worth our notice in the Nymph, whoſe figure we are now conſidering: this is, that I have repreſented its fore-parts, about the head, ſomewhat whiter and brighter than the reſt of the body; becauſe the hidden Nymph, by the inſenſible evaporation of its moiſture, gradually contracts itſelf more in this part than elſewhere, ſo as to leave a vacant ſpace, which, by affording a free paſſage to the rays of light, thereby, in reality, acquires an extraordinary degree of brightneſs. This particular I took notice of in a Nymph, like this I am now deſcribing, of the Muſca Aſilus, or Gadfly, whoſe hiſtory follows this. It is likewiſe plain, that the empty part of the ſkin, in the foregoing Nymph, may be dexterouſly cut off with ſciſſors, without wounding the encloſed inſect; and, upon doing ſo, we may ſee that the Nymph's head lies in the fore-region of the Worm's ſkin; and that its eyes, which, in the beginning of the change, were of a milky white, are at this time turned to a purpliſh red. However, this experiment ought only to be tried upon Nymphs which are ſeveral days old; for we ſhould certainly injure thoſe that were younger, in the operation. It happens in this Worm, as it does in all others of the fourth order, that the thorax conſtantly continues the ſame in the Nymph-ſtate, without any viſible alteration: in the ſame manner, as in Worms and Caterpillars of all the other orders, the legs, ſpringing from the thorax, never change their ſituation. But this laſt circumſtance chiefly obtains in the ſecond order, of which there are a great number of inſects, whoſe thorax, and eſpecially the legs belonging to this part, do not ſuffer the leaſt alteration; that is, they neither grow longer or ſhorter at the periods of the inſects caſting their ſkins.

FIG. V.

I here give a figure of the enclofed hidden Nymph, as it appeared fomewhat magnified, when cut out of the external skin, or that of the former Worm, which before covered it.

FIG. VI. and VII.

Thefe two figures reprefent the fame Nymph magnified by the microfcope to a proper degree. We may fee in thefe in what manner it is divided into a head, thorax, and belly, which I fhall more particularly explain in the next figure, which likewife exhibits the fame Nymph.

Fig. VII. *aa*. Are the infect's eyes feated in its head, and formed like a net; between thefe, but lower near the thorax, appears its probofcis, or trunk.

b. Are two little horns or antennæ, which arife from the upper part of the head.

cc. The folded legs rifing from the thorax, three on each fide.

dd. The folded wings, between which the extremities of the legs are clofely arrayed.

e. The annular divifions of the abdomen, and certain prominent tubercles upon the edge of it, being what remains after the infect cafts the skins of the feathered protuberancies of the Worm and Nymph, which I have abovementioned. Thefe tubercles difappear when the creature affumes the form of a Fly. They are either entirely deftroyed by the evaporation of the humours, or thrown off by the hairs that grow in this part. It is a very tedious and difficult task to diffect the real Nymph of the tender membranaceous skin, which immediately covers it under the outer integument, without either hurting or difplacing its limbs.

FIG. VIII.

This figure exhibits, larger than life, the Nymph free from its two coverings, and changed to a Fly; but it muft be obferved, that it does not, on parting with its fkin, fold or curl them up, as Hornets and Bees do; this creature only breaks them near the place where its head lies, and leaves the cafe unimpaired in every other refpect: fo that on feeing one of thefe deferted coverings, one would be apt, at firft fight, to take it for an entire Nymph. This Fly, which from the form and condition of a contemptible and filthy bog-houfe Worm, is changed to an inhabitant of the air, thus making mifery its way to happinefs, is divided in a very diftinct manner into the head, the thorax, and the abdomen.

Fig. VIII. *aa*. In the head are two eyes formed like an elegant piece of net-work, and of a purplifh colour. Thefe eyes are feparated by two very elegant zones of a filvery whitenefs, in the part where they come neareft to one another.

b Between thefe filvery zones, on the forepart of the head near the eyes, are the infect's two horns, or antennæ.

cc It has likewife two membranaceous wings fixed to the fhoulder-blades of the thorax.

dddd Are fix legs covered with ftiff hairs; thefe are articulated with the lower part of the thorax, and they confift each of four joints: that which forms the foot, properly fo called, is again divided into feveral leffer joints. We may, befides, fee very diftinctly, that every leg has diftinctly two claws at its extremity, and that thefe claws are parted by fome hairs that grow between them.

e Here we may fee the rings and variegations by which the abdomen is divided. They are covered with hair refembling briftles. Indeed, the whole body is thick fet with this kind of hair, and it is of a blackifh gray, without any other particular ornaments of colour, tho' in many other Flies we perceive a moft delicate mixture and combination of colours; fo that the Fly now under confideration, deferves only to be ranked amongft the moft ordinary fort.

FIG. IX.

Finally, to give a perfect idea of this fourth order of mutations, I fhall add a fuccinct account of two particular Nymphs, which belong to it, tho' under the fecond mode; for thefe Nymphs differ greatly from thofe of the fame order already defcribed: they are altered in a great meafure from the fhape they had in the Worm ftate, tho' one of them much more than the other; the reafon of which variation I fhall likewife endeavour to point out.

Tab. XXXVIII. FIG. IX. A.

The Worm here reprefented, is the fame with that of which Goedaert has given us a defcription, and a figure in the firft part of his work, obfervation 11, but without taking any notice of its feet or horns, both which he overlooked. I cannot fay, that I have myfelf counted thefe feet in a living Worm; but on examining a preferved one, and its Nymph, there appear feven on each fide, and thofe are all armed with fome little claws. Thefe feet are very fhort, and fcarce vifible, except when the infect extends and thrufts them out. Goedaert does not deny the exiftence of thefe feet, in his Dutch work, publifhed under his own infpection, but his Latin tranflators do it for him: from whence it plainly appears, that thofe gentlemen, who have likewife added their own obfervations to Goedaert's work, have difgraced his performance by a great many errors and miftakes. We have reafon alfo to lament, that this induftrious naturalift employed others to write, even in Dutch, the obfervations which he had made in this province of natural hiftory. We muft expect to find their particular opinions frequently intermixed with thofe of the illuftrious original writer. But be that as it will, one thing is certain, that the original Dutch is preferable in correctnefs, and other refpects, to the Latin tranflation.

The two antennæ, or horns of this Worm, which it carries on the forepart of its head, and its long tail, which it fometimes twifts and turns about in a very furprifing manner, contribute greatly to give it a fingular and pretty appear-

appearance.* Its body is divided into feveral rings, which fometimes appear much rounder than at others. The colour is of a sky gray, approaching a little to brown. It is a miftake to think, this Worm proceeds from putrefaction, as Goedaert, or rather his commentators have advanced. It is produced from an egg depofited in bog-houfes by a Fly like that, to which it is itfelf one day to be changed. I have fometimes alfo found thefe Worms crawling in vaft numbers, and in a ftrange manner amongft one another, in meadows, in barns, and among very moift cow-dung. Thefe infects are of a very flow growth; fo that they do not change till the month of Auguft. I have hitherto taken but a very curfory furvey of their internal parts; their pulmonary veffels appeared to me to be thofe that beft deferved further obfervation.

B.

When thefe Worms are about to affume the appearance of Vermiform Nymphs, as is reprefented in the ninth figure, under the letter B, they remove themfelves out of the excrements wherein they have hitherto lived, to fome dry place, where they draw all their parts together. I have even fometimes obferved thefe Worms fixed to the walls of country cottages, where they had climbed up to twice a man's height, in order quietly to go through their mutations. This important bufinefs is executed in the following manner. Firft, the Worm's tail is wrinkled up, and contracted by drying, and fometimes it curls itfelf up, fometimes not; fometimes even it grows quite flat by drying, as it hardens to a greater or lefs degree, or as it has taken up more or lefs time in hardening; then the reft of the body becomes wrinkled up, and fo contracted, that its rings are in a manner forced together into one. But as the skin of this Worm is fomewhat foft, it conforms to all the fhapes that the hidden Nymph affumes in its progrefs towards the Fly-ftate; and this is the true reafon why this Vermiform-nymph deviates a little from the appearance of the former Worm. I fay a little, becaufe we may ftill perceive in it, the skin of the Worm, its tail and legs: but above all, the antennæ, or horns differ; which in this Vermiform-nymph project more from the head, than they did in the Worm itfelf; befides this, from being foft and pliable, they become hard and ftiff at this time. By dexteroufly opening the external fkin at this period, we may obtain the true Nymph it conceals in fuch great forwardnefs towards the Fly-ftate, that it exhibits diftinctly the parts peculiar to that creature, the horns or antennæ efpecially, which are difpofed, as in a cafe, within thofe of the former Worm.

C.

When the Nymph we are treating of, has thus lain hid for about fixteen or feventeen days in the unaltered fkin of its Worm; it is fufficiently grown and changed to appear abroad, and fo at once forces its way in the form of a perfect and very handfome Fly thro' the faid fkin, and the internal membrane immediately invefting it; as is common to the infects of this fourth order. This Fly is beautifully divided into the head, thorax, and abdomen; it has two eyes, two little antennæ or horns, fix legs, a pair of wings, and its body is covered with hair. Its back and tail are yellow and red, delicately interfperfed with black fpots: it is reprefented in the ninth figure, under the letter C.

Some authors have fancied, that this infect ought to be ranked amongft Bees, as appears in Clutius's treatife on Bees, where he cautions the unexperienced againft fo grofs a miftake. However, Dr. J. de Mey, regardlefs of fuch notice, falls into this error in his notes upon Goedaert, where he prodigioufly magnifies the hiftory of this infect as a real Bee. In this he gives evident proof of his little acquaintance with either the Bee or the Fly-kind. Thus the vain temerity of our corrupt nature makes us attempt to pafs our judgment upon things of which we know nothing; with a view of paffing for perfons of knowledge and wifdom upon others as ignorant.

FIG. X.

I here reprefent a Worm, that has pierced the fkin of a Chryfalis, like that exhibited in Tab. XXXVII. N°. V. and has deferted it afterwards in fearch of a more proper place in which to perform its changes.

D.

This Worm is divided by a great many annular fections. Its colour is white; its skin is foft and tender. It moves itfelf by the annular contraction and extenfion of its rings, and it continues this motion in its prefent ftate, till being quite fpent, it quietly lies down to give way to the fecret operations of nature, in the change of its condition.

E.

While this is preparing, we may obferve, that the head and tail of the Worm are drawn up, as it were, into its body, though as yet no change happens in the old fkin, except its affuming the fhape of an egg, in which, foon after, there appears a variety of colours; firft, the body then fhrivelled up grows white, then yellow, next red, after this of a purple colour, which then acquires a fiery brightnefs, like that, as it were, of a fparkling red, fhining like amber; and, laftly, it turns to a deep brown, which it retains for fome days without any further alteration.

On laying open and removing the fkin of the Worm at this period, we find in it a true perfect Nymph, which exhibits moft diftinctly all the limbs of the future Fly: fo that this is a real Vermi-form Nymph, only that it yet reprefents the parts of the former Worm, though in a fome-

* We have in England three diftinct fpecies of thefe Worms; the French alfo have them as common, they call them Vers a que de Rat. They are the offspring of three diftinct fpecies of Flies, all refembling Bees, but with only two wings. The fpecies here defcribed, is the largeft; and it changes into a large Fly, which our obfervers of Infects call the Drone Fly, from its great refemblance of the male Bee, which is alfo called the DRONE.

what

what obfcure and confufed manner: this is owing entirely to the foftnefs and delicacy of its fkin, which fticks clofe to the furface, and accommodates itfelf to the fhape and figure of the enclofed Nymph.

By duly attending to the preceding obfervations, we may for the future eafily underftand, for what reafon fome of thefe Nymphs retain the figure of their former Worms more than others; for, it will plainly appear, that this difference arifes folely from the fkins of the former Worms, being more or lefs hard or pliable. For thofe Worms, that have a very dry and hard fkin, as the Worms of the common bog-houfe Fly, and the Mufca Afilus, or Gad-fly, cannot but retain their former appearance; whilft other Worms of a foft and delicate skin, cannot but lofe a great deal of it; all which is made evident, by a remarkable example in the tenth figure, under the letter E.

Such being the nature of thefe things, we may plainly perceive how much thofe naturalifts were miftaken, who called the foregoing condition of the limbs, and other parts, a true egg, as may be feen in Mouffet, and Goedaert, in the commentators of this laft, and many other authors. But let no one imagine, that I mention this miftake, in order either to expofe the writers, who have committed it, or to deferve glory from their ignorance: my fole intention is to publifh truth, and excite thofe who love it, to fearch after it in the works of nature themfelves; for they are capable of teaching us more in a fingle moment, than all the written accounts of them could do in a thoufand years.: but then we fhould prepare ourfelves for fuch an inquiry, particularly by laying afide all manner of prejudice, as it plainly appears, that obfervations attempted upon a wrong foundation, have only ferved to produce a great number of pernicious errors.

F.

To conclude, I prefent the reader, under the letter F. of the fame figure x. a reprefentation of the Fly produced from the Nymph I have been laft defcribing. It is like the common Fly, divided into the head, the thorax, and the belly. Between the eyes, which are feated in the head, and are of a deep purple colour, are two filver borders or zones; and between thefe borders are placed a pair of antennæ, or horns. From the fhoulder-blades arife two grayifh membranaceous wings, and from the fore-part of the thorax, fix hairy legs. The abdomen is covered with hair, like briftles, and is divided by feveral rings, parted from each other by black rolls or bandages. This Fly, like the preceding, on its quitting the Nymph-ftate, leaves two skins behind it.

As to the manner in which this fpecies depofits the eggs within the Carerpillar, reprefented in No. III. of the XXXVIIth Table, and the courfe in which the Worms arifing from thofe eggs, are changed into Chryfallides with the Caterpillar, upon which they feed; or, to fpeak more properly the manner in which thefe fmaller Worms come to be enclofed in the Caterpillars Chryfalis, and their management in forcing their way thro' this Chryfalis, I fhall give a general account of in the progrefs of my furvey of this fourth order, and hope I may fome time, or another, have an opportunity of handling this fubject more particularly, and folving the gordian knot which it contains.

The furprifing hiftory of the infect called the Mufca Tabanus, or, more properly, the Afilus or Gad-fly *.

THE INTRODUCTION.

THE Infect, whofe hiftory I am about to give under the name of the Gad-fly, is fo wonderful in all its parts, that it may be well ranked amongft the moft mafterly works of nature; for, the particulars which induftrious obfervers have difcovered in it, are moft fingular, and unheard-of in other kinds. The learned Mouffet inveighs feverely againft thofe authors, who confound this Fly with the Tabanus or Breeze-fly, as he affirms there is an effential difference between them, which I have myfelf alfo found to be very true; for, as the faid Mouffet very pertinently alledges after Ariftotle, the Afilus or Gad-fly, proceeds from a certain little, broad and water infect. This author remarks alfo, with equal propriety, that the Afili or Gad-flies are much more fcarce than the Tabani or Breeze-flies, and they are not to be found except in the neighbourhooud of rivers, and they have a much larger probofcis or trunk than the Tabani or Breezes. This being fettled, the Fly that I am here now about to defcribe, is a true Afilus or Gad-fly, and ought, by no means, to be calleda Tabanus, or Breeze-fly; for, agreeable to the defcription given of the Afilus, or Gad-fly, it proceeds from a little flat water Worm; it flies about fields near waters; and, in fine, it has a larger trunk than the Tabanus or Breeze-fly. Mouffet has given us a true figure of the Tabanus or Breeze; and at the fame time, has affigned the real difference between that and the common Horfe-fly; for there are many fpecies of Horfe-flies, and the Tabanus or Breeze ought to be accounted one of them. But Mouffet is greatly miftaken in giving the Afilus a hard fnout, with a ftrong fting or aculeus fixed to the fore-part of it, thefe particulars being obfervable in the Tabanus or Breeze-fly only. He errs as much in faying, that the Tabanus grows at the end of honey-combs. But it was impoffible, that this author fhould not

* The common writers have been very confufed in their accounts of the two fpecies of infects known by the names of the Gad-fly and the Breeze-fly, and have applied the names at random, to one or the other. The Latin denominations of the fame infects, Tabanus and Afilus, have been as ill defined. The creatures are perfectly diftinct, both in the Worm and Fly-ftate, and, 'tis to be hoped, that, for the future, they will be fo underftood and confidered, this author having perfectly diftinguifhed the words, and afcertained their meaning by his figures.

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commit miſtakes; for, as he had no experience of his own to go by, he was obliged to take things upon truſt from other writers, and conſequently was liable to adopt their errors.

I muſt, on this occaſion, deſire my readers to take notice, that in my general hiſtory of inſects, I forgot myſelf ſo far as to deſcribe the Aſilus, under the name of Tabanus; nor can I account for this overſight, as I then made uſe of the words of Ariſtotle juſt now cited. After this preface and remark, I ſhall briefly deſcribe the little creature, from which our Aſilus or Gad-fly proceeds. It is repreſented in Figure I. of Tab. XXXIX. its Nymph in the II and III Figure of Tab. XLI. and laſtly, the Aſilus Fly itſelf, in the II Figure, Tab. XLII.

There are ſeveral very uncommon particulars in theſe ſtates of the ſame inſects in the Worm condition; it lives in the water, breathes by its tail, and carries its legs within a little ſnout near its mouth. When it becomes a Nymph, it performs the change without caſting its ſkin; and when it becomes a Fly, it can no longer live in the water; ſo that the element, which hitherto ſupplied it with life and motion, would now be its immediate deſtruction.

Theſe are all no more than the external wonders; and they appear inſignificant, when compared with the hidden changes and tranſpoſitions of parts, performed within the skin, ſtomach and inteſtines, but above all, in the ſpinal marrow, which it is impoſſible to ſee, without being loſt in aſtoniſhment.

There occur beſides in this treble, though at the ſame time ſingle, little creature, other particulars, ſurpaſſing, in a manner, all human imagination; ſuch as its moſt uncommon alterations of colour, indurations of parts, loſſes of limbs, and acquiſitions of internal organs.

Thus I ſhall cloſe this ſhort introduction, but I cannot too often remind my readers, that they will here meet with a collection of wonders, any ſingle one of which, is worth their moſt perfect attention. Nor are they the lines only of an Apelles, that I deſcribe in this place, but inimitable pictures, and the very handy-work of the great Creator, God himſelf, to whom we are indebted alſo for all that we have, or are, and whom we ought to acknowledge in the humbleſt manner, as our Creator, Preſerver, and conſtant Benefactor. Hence, judge, O man, how incomparable muſt be the elegance of thoſe miracles of his, which ſhall never periſh, when ſo much art and contrivance is to be ſeen, even in the corrupt nature of creatures, that are buried, as it were, under darkneſs, by his great ordinations. Therefore to this all-good, all-wiſe, and all-powerful Being, and to him only, be all the honour and glory of the preſent diſcovery.

CHAP. I.

The external figure of the Worm, from which the Muſca Aſilus, or Gadfly, is produced, repreſented in its natural bigneſs; and alſo as it appears when magnified by the microſcope; with the manner of its carrying its legs, by a moſt wonderful contrivance, in its mouth; and of its breathing by the tail.

Tab. XXXIX. Fig. I. *a.*

THIS Worm, viewed with the naked eye, appears to conſiſt of twelve annular diviſions, *a*, by which it is ſeparated into a head, thorax, and belly; but as the ſtomach and inteſtines lie equally in the two, the thorax and belly, their bounds are ſcarce perceivable, until the inſect, ſtill cloathed in the Worm's ſkin, approaches the Nymph-ſtate.

The parts moſt worthy of notice, that the naked eye can diſcern in this Worm, are its tail and its ſnout. The tail is furniſhed with an elegant crown *b* or circle of hair, diſpoſed quite round it in an almoſt annular form; by means of which, while the Worm moves itſelf in the water, this tail can ſupport itſelf on the ſurface, the body all the time hanging down towards the bottom; and ſometimes it remains thus a long while, without the leaſt ſenſible motion. The ſnout is divided, as it were, into the three parts, *c*, of which that in the middle is altogether immoveable; whereas the two others, which grow at the ſides of the former, vibrate in a very ſingular manner, and, in appearance, are very like the tongues of Lizards and Serpents. The greateſt ſtrength of the Worm is likewiſe ſeated in theſe lateral parts of its ſnout: it is by means of theſe it crawls, when out of the water, ſo that one would imagine it walked with its mouth. Parrots, whoſe upper and under jaws are both moveable, enjoy, in the ſame manner, the privilege of uſing their beaks with ſuch force, in climbing, that they have the greateſt advantage from it. In the ſame manner this Worm, as often as it can lay hold of any thing with thoſe parts that I have been ſpeaking of, appears to move, as it were, entirely by the help of its ſnout. Theſe parts, however, do not conſtitute its mouth, as I ſhall preſently ſhew.

When the Worm, being thus ſupported on the ſurface of the Water by means of its tail, has a mind to ſink to the bottom, it generally bends the hairs of that part a little towards each other in the middle, and much more forcibly at the extremities, without diſturbing them in the leaſt about the roots. By this means a hollow is formed; and the air, pent up in it, looks like a pearl, Tab. XXXIX. Fig. II. *a.* It is by the help of this bubble that the inſect can again gently raiſe itſelf to the ſurface of the water, and there remain ſuſpended. The fame thing has been obferved in thofe Worms that produce Gnats. If at any time the air fhould happen to efcape from between the hairs forming this bubble, the infect has the power of immediately replacing it, by a new fupply from its pulmonary tubes; and fometimes even large quantities of air are feen to arife in bubbles from the tail of this Worm, *b*, to the furface of the water, and mix with the incumbent atmofphere. This is owing to the water's being fo much heavier than air; it being natural for things, though heavy in themfelves, to afcend, in order to make way for thofe that are more fo.

This extraordinary operation may be eafily feen at any time, by putting the Worm into a glafs full of water, and it affords a very entertaining fpectacle; for the air-bubble, enclofed in the tail, looks like a little tranfparent filver bladder. I have four fpecies of this Worm, and of the Fly that is produced from it, all differing in fize and colour; but without any other confiderable diftinction.

As all I have as yet faid concerning this Worm, which produces the Afilus-fly, can give but an imperfect idea of it, I fhall exhibit it alfo as it appears through the microfcope; and, at the fame time, defcribe its external and internal parts. Thus the reader will be enabled clearly to comprehend the defign and ufe of thofe little parts, which are fituated near the tail and the mouth; as alfo, after what manner its lungs receive the air, which is both admitted and difcharged by the tail. Finally, I fhall make it evident, that thofe are really the infect's legs which are feen moving near its mouth, like the tongues of Serpents.

Fig. III.

On examining the external figure of this Worm with a microfcope, it appears to be a little pointed forwards about the head; and its thorax, or that part of it which we may confider as fuch, is fomewhat broader. The body again grows fmaller, and converges at the abdomen; till at laft it ends in a fharp tail, elegantly furrounded with hairs, in the form of the rays of a ftar.

This Worm, the head and tail included, has twelve annular divifions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. Its fkin refembles the covering of thofe animals which Nature has provided with a cruftaceous habit, much more than it does that of Worms, or of the naked Caterpillars. It is moderately hard, and, like that rough fkin called chagreen, it is thick fet with an infinite number of fmall grains, pretty evenly diftributed. Thefe grains lie fo clofe together, that there is not to be found the leaft vacant fpace between them; and they are fmaller in thofe parts, where the rings of the abdomen are pointed to each other, than upon the middle of the rings. This difpofition renders the fkin more flexible, and confequently facilitates the turnings, and other motions, of the Worm's body. The true conftruction of thefe grains is feen, on viewing them with the greateft magnifier, Fig. IV. and I give a feparate drawing of them upon a fmall portion of the fkin. This figure alfo fhews us how the fkin, *a*, looks in the interftices of thofe grains. Thofe grains are very thick, and convex in the middle, *b:* near their edges they appear as confifting of many rings, *c*, which join each other; and form a great many irregular points, *d*, fo as to add great ftrength and firmnefs to the grains themfelves. The fubftance of thofe grains is a very firm horny bone; and I make no doubt but the fkin of this Worm might be made ufe of, in turning, to polifh the harder woods, as ebony and box, in the fame manner that the fkin called chagreen, juft now taken notice of, is fuccefsfully applied to the fame purpofe.

There are alfo nine puncta refpiratoria, breathing-holes, or points of refpiration, on each fide of this Worm's body; but I here reprefent only twelve of them, nine at one fide, and three at the other. There are no fuch holes vifible on the outfide of the tail, Fig. III. *a*; nor in the third ring, counting from the head: for the tail has, at its extremity, openings for the admiffion and expulfion of air, as already taken notice; and in the third ring the breathing-holes only appear under the fkin, and are very fmall, as it is hereabouts the embryo wings of the future Fly lie concealed. It is very remarkable, that this Worm fhould have but one ring without thofe breathing-holes; whereas Caterpillars always have two without them. The reafon of this difference feems to be, that moft Caterpillars change to Flies with two pairs of wings; whereas the Worm, under our confideration, changes to a Fly that has but a fingle pair.

Above thefe pulmonary openings, there befides appear a great many black fpots; but they are much fmaller than thofe formed by the breathing-holes. Thefe leffer fpots feem intended merely for ornament. They fhed a fkin, fo that they are ftill feen in the infect, when arrived at the Nymph-ftate.

The fkin has only three colours: it is adorned with oblong black furrows, fpots of a little lighter colour, and orbicular rings; from the middle of which there generally fprings a hair. In the figure before us, only the hairs that grow on the infect's fides are reprefented, Tab. XXXIX. Fig. III. *b b*; for to exhibit them all, would require too large a drawing. Befides the hairs already mentioned, there are here and there fome other larger hairs, *c c*. All the variety of colours perceivable in this infect, proceeds from this; that the colour of the grains is fomewhat deeper or paler in fome places than in others; for there is no material difference between them, in point of fize. According, therefore, as the number of grains is greater or lefs, or the colour of them is darker or lighter, the furrows and rings are of a deeper or paler colour.

The head of this Worm, *d*, is, as it were, divided into three parts, and covered with a fkin, the grains on which are hardly difcernible. The eyes, *e e*, lie forwards near the

fnout,

fnout, and are fomewhat protuberant. It has likewife two little horns, *i i*, on the fore-part of its head. The fnout itfelf is fomewhat crooked, and ends in a very fharp point, *f*; but what is altogether fingular and furprifing, and no doubt, if I may fay fo, is moft wifely contrived by the Great and Almighty Architect, is, that this infect's legs are placed near the fnout, between the finufes in which the eyes *g g* are fixed: fo that, at firft fight, I imagined this Worm made ufe of its fnout, as Parrots do of of their bill, to faften upon whatever it pleafed, and move itfelf from one place to another; but I have fince learned by experience, that thofe parts are real legs, which is altogether as furprifing as if a fmall pair of hands, one on each fide, fhould be feen growing in a man from the infide of his jaw-bones *.

Each of thofe legs confifts of three joints; the outermoft of which is covered with hard and ftiff hairs, like briftles. From the next joint there fprings a little horny bone, *h h*, which ferves the infect for a kind of thumb: the joint itfelf is likewife of a black fubftance, between bone and horn in hardnefs; and fo is the third joint. But thefe particulars cannot be fo well diftinguifhed on the outfide; for which reafon the parts that form the upper fides of the mouth, and the eyes, muft firft be difplaced with a very fine fmall knife. This done, we may plainly perceive, by the help of a microfcope, that the leg is articulated by means of fome fingular ligaments, with that portion of the infect's mouth, which anfwers to the lower jaw in the human ftructure. We may alfo, by this method, difcover the mufcles which ferve to move the legs, and draw them quite up into the cavity that lies between the fnout and thofe parts of the mouth, near which the horns, *i i*, are fituated.

I have taken the pains to draw five of thofe mufcles adminiftering to the infect's leg, which are very diftinct. Three of them, Fig. V. *a*, are continued by their tendons, in form of a black fubftance between bone and horn; and after this, growing fofter, are inferted *b* into the infide of the greateft joint of the leg, which is of the fame kind of fubftance with the tendon. The other two mufcles, *c*, had their infertions on the oppofite fide of the fame joint. The mufcles which move the other joint, *d*, are inferted into that large horny joint already mentioned; and in this joint alfo are to be feen the latent mufcles, which move the extreme joint of the leg, *e*, with its briftles, and its thumb, which I here likewife reprefent, *f*. This figure fhews, at the fame time, in what manner the foot is furrounded with hair. This infect not only walks with the legs I have been defcribing, at the bottom of the water, but even moves itfelf on land by means of them. It likewife makes ufe of them to fwim with, while it keeps its tail on the furface contiguous to the air, and hangs downwards, with the reft of its body in the water. In this fituation, no motion can be perceived in it, but what arifes from its legs. At this time alfo it plies them fo elegantly, that, to the naked eye, they appear like the vibrating tongues of Serpents. Hence we may conclude, that the greateft ftrength of this Worm lies in thefe parts; and we may be likewife convinced, that it exhibits in a fingular manner, and more fully than many other animals, the wonderful contrivance and execution of the Divine Power and Wifdom.

The fnout itfelf, Tab. XXXIX. Fig. VI. *a*, is very black, and of a fubftance between bone and horn. This may beft be feen by turning the infect on its back: in this fituation alfo we can difcover the crooked point of the fnout, *b*, near which the jaws open themfelves, *c*, and offer to our fight the gullet or throat, and all the other parts of the mouth. Here likewife we may obferve three membranaceous divifions in the fnout, two of them running tranfverfely, one at each fide, *d d*; and the third ftretched lengthwife between both: by means of thefe divifions, affifted by the mufcles contained in the fnout, the Worm can at pleafure expand or contract that part. But the back-part of the fnout, *e*, is quite folid, and made up of a black fubftance between bone and horn, and of a rounded and fomewhat globular form; whereas the fharp part that lies forward, which I have before reprefented on the fore-part of the head, Fig. III. *f*, is hollow.

The tail is moft artfully imagined and conftructed. Its extreme verge, or border, is furrounded by thirty hairs, and the fides of them are adorned with others that are fmaller. Here and there alfo, fome of the bigger hairs branch out into others, each of which I reckon as a fingle hair. Thefe hairs are all rooted in the extreme fkin of the tail, which, in this place, is alfo covered with rough grains; as may be feen by cutting it off, and holding it up, when dry, againft the light, upon a thin plate of glafs. It appears likewife, by the fame means, that the hairs of this part have, at their very extremities, grains alfo, like thofe upon the fkin; though I could never yet get a diftinct fight of them through the beft microfcopes. In the middle of the tail is a little opening, within which there are two fmall holes; by which the infect takes in and lets out the air it breathes. It feldom happens, that the hairs of the tail are fo regularly difpofed on the furface of the water, as I have here reprefented them, unlefs when the Worm but juft floats with its body in the water, and the tail with the hairs belonging to it are a little lower than the furface; for then thefe hairs difplay their extremities, in the diftinct manner that I have here reprefented them: and the leaft motion downwards of the tail, at this time, occafions

* Thefe fingular and amazing Worms are very common with us in fhallow ftanding waters. I found millions of them this year in a pond, in a field acrofs the road on the right hand of Liffon-Green, near Paddington. They will live many weeks in a glafs of water, and fhew all their amazing qualities; confirming, in every inftance, the accuracy and truth of this author's accounts. A microfcope fhews very beautifully the motion of their inteftines; and few infects afford a more beautiful object.

a confiderable pit or hollow in the water; whilft the tail itfelf affumes the figure of a glafs, wide at top, and ending at the bottom in a point. Hence it is manifeft, that this tail ferves the Worm for both the purpofes of fwimming and breathing. Thus then, O wonder of wonders! this creature receives by its tail the univerfal principle of life and motion in animals. And the better to anfwer fuch an important ufe, thofe hairs are fo myfterioufly conftructed, that, let them lie under water ever fo long, they never contract any moifture, the water running off of them the very moment they reach the furface. Another advantage the Worm has in thefe hairs, is, that, when fwimming, it can by means of them immediately ftop itfelf, and fo remain quietly fufpended in the water as long as it pleafes.

CHAP. II.

Of the actions or motions of this Worm; the places where it is found, its food, and the manner of killing it for diffection.

THE motions which this Worm makes in fwimming are extremely beautiful, efpecially when it advances with its whole body floating on the furface of the water, after filling itfelf with air by the tail. To fet out in this pofture, it firft bends its body to the right or left; then contracts it in form of the letter (S); and laftly, or lying flat upon its belly, it ftretches out the body again to a ftraight line. By thefe alternate bendings, contractions, and extenfions, it moves along upon the furface of the water; and as its motions are very flow, it will hold out for a long time in this manner.

Thefe Worms are no way difturbed on being handled in the water; though they cannot fuffer the touch of other Worms, even thofe of their own fpecies, without agitation, when fwimming amongft each other. From this circumftance we may conjecture, that they are provided with a ready inftinct to difcover whether what comes in their way is likely to do them any harm. Be that as it will, I drew great advantages from this quiet difpofition of the infect, as it afforded me the better opportunities of examining it by the microfcope, and making a fatisfactory figure of it.

At the time when thefe Worms float on the furface of the water, it is impoffible to drive them under it, fo as to make them continue there, on account of the great quantity of air with which they are then fwelled. But on expelling this air by the tail, they of themfelves immediately fink to the bottom; nor can they again make themfelves float on the furface of the water, till, having rifen to it, they expand the hairs of their tail, and take in another draught of air.

On taking thefe Worms out of the water, all their motion feems confined to the head, becaufe it is only by the help of their legs, which are fituated there, that they can ftir in this fituation. But as it is neceffary, for that purpofe, that the head fhould bend at the fame time, one would, at firft, imagine they make ufe of their mouth to walk with; whereas, in reality, their progrefs is entirely effected by the feet only.

Thefe Worms are to be found about the beginning of June, fooner or later, according as the fummer is more or lefs warm, both in falt and frefh waters. Sometimes great numbers of them offer themfelves, as it were, of their own accord to our inquiry; whilft in other years, it is no eafy matter to meet with them. They are common enough in the ditches of grazing grounds, efpecially in fuch parts of thofe ditches as here and there contain little patches, or iflands, covered with grafs and other plants, through which, and upon it, thefe Worms love to crawl. They are often too, to be feen in the cracks of our ditch-banks, where they float upon the furface of the water, by means of their tail, with head and thorax hanging down: and in this fituation they will turn over the clay and dirt with their feet and their fnouts, as thofe parts are fo near each other, in fearch of food.

It is thus thefe Worms look out for their nourifhment, which is principally a kind of vifcous matter, to be met with in little pools, and about the fides of ditches; for thefe infects are never feen in large and deep waters, fo that, whenever it happens that the ditches are quite full, the Worms, to come at their food, either betake themfelves to the bottom, or venture on fhore, in queft of fomething to live upon. It is very remarkable in thefe infects, that, when they lie under water, they very often drive air into the cavity formed by the hairs of their tail; which cavity, on being thus blown up, looks like a tranfparent pearl moving in the waters; at the fame time that, by becoming the lighteft part of the infect, it keeps uppermoft, and thereby affords the feet and the fnout a better opportunity of providing for the infect's fupport.

This little infect is exceeding harmlefs; it neither bites or wounds, or otherwife does any mifchief; contrary to the opinion, one might at firft fight be apt to form of it, on account of the furprifing vibrations of the legs, placed in its head, which fo much refemble the brandifhings of an envenomed tongue or fting: but fuch notions appear altogether wrong on further examination; for the opening of the infect's mouth, at which it fucks in its food, is feated within the bending of its fharp pointed and crooked fnout.

I find that clay and foft earth are the food of this infect; though I have likewife fometimes found

found in it, on diffection, little red ftones, and fmall grains of fand intermixed: I am not able to explain, on account of the narrownefs of this infect's mouth, how it could poffibly take in fuch large and hard fubftances. This induces me to think, that it only fucks in the fubtile vifcous particles of earth, mud, and clay, which afterwards undergo various mutations in the ftomach, as I fhall hereafter endeavour to fhew, in the anatomy of this Worm, and the Nymph produced by it, where I fhall alfo relate the manner how the very inteftines of this infect caft their fkins.

I have tried many methods of killing thefe Worms, in order to examine them anatomically. Spirit of wine does not fo well anfwer this purpofe; for they live in it a day and night, or perhaps longer; but I cannot affirm any thing pofitively on this head, as I grew tired of wafting my time, that I could otherwife fo well employ, in watching them. Some of them that I threw into rain water, after taking them out of the fpirit of wine, together with others, continued alive feveral days, till I had opened them all, while living, in order to view their parts, and found myfelf under a neceffity of looking out for a frefh fupply. In vinegar alfo thefe infects held out a long time, and they moved more brifkly in it, than in water; they would fometimes alfo crawl out of it. Some of them endured this trial for two days and a night, and fome a longer time, whilft others expired fooner. But hardy as their conftitution may be, they die in fpirit of turpentine in lefs than a quarter of an hour. It is very curious to obferve, at this time, how the air contained in them remains, in appearance, fixed between their hairs, and the divifions of their body, fo as perfectly to imitate the appearance, as it were, of tranfparent filver.

The induftrious Goedaert, as far as I can guefs by his drawings, give us one of this Worm; as alfo a defcription of it in the firft part, and feventieth experiment of his natural metamorphofis; but he forgets to tell us whether it belongs to land or water: nor is there among all his obfervations concerning it, any thing remarkable, except its being able to live for nine months without food. On this account he calls it the Chameleon, impofed upon by the vulgar opinions of the land-animal of that name, living entirely upon air.

We have likewife, in the learned Aldrovandus, a figure and a defcription of this Worm, under the name of the Water Inteftine. But this author knew nothing of its changing to a Fly, or of the other furprifing particularities, which I have obferved in it.

CHAP. III.

The anatomy of this Worm, giving an account of its teeth, ftomach, inteftines, falival veffels, pulmonary tubes, fat, heart, brain and mufcles.

THE internal parts of the Worm, which produces the Afilus or Gad-fly, are the teeth, gullet, ftomach, thick and flender inteftines, falival veffels, pulmonary tubes, fat, heart, brain, fpinal marrow, nerves and mufcles; each of which I fhall now feparately defcribe. The teeth are feated in the back part of the mouth, as in many fifhes, fo as to enable the infect, after it has taken in any food, to grind it properly before it gets down into the ftomach. I have by me fpecimens of Hermit-fifh, and large Crabs, which have teeth in the very cavity of the ftomach. The teeth of the infect now under confideration, are of a fubftance between bone and horn, and their furface is in many places rough and unequal; but thefe afperites are not confiderable enough to be taken notice of in the figure. The gullet is a very flender channel, running from the jaws and mouth to the ftomach, through a fiffure or opening in the fpinal marrow, contrived on purpofe to give it free paffage: this is likewife the cafe in many other infects. For this reafon, the brain of this Worm lies, as it were, upon the fore-region of the ftomach. The ftomach itfelf appears as a fmall membranaceous particle, and is found full of the half-digefted food, on killing the Worm, in fpirit of turpentine, as foon as it is caught, and then diffecting it. The flender inteftines alfo appear, on this occafion, filled with the fame fubftance. In this fpecies of Worms, the ftomach and flender inteftines are about five Dutch inches in length; or to ufe Mr. Thevenot's method, they are equal to five rows of regular cells of Bees, built one againft another, five in a row. Mr. Thevenot imagined, that by means of fuch cells, an univerfal meafure for all nations might be difcovered, fuppofing fuch cells were every where equally regular, and of an equal bignefs. I muft here obferve, that there is very little difference between the ftomach and inteftines of this infect.

Towards the extremity of the flender inteftines are four vafcula varicofa, or cæca, or little guts or appendages clofed at the end: thefe are fituated equally in the abdomen and thorax, which fometimes contain an aqueous fluid, and fometimes a bright white fubftance, like coagulated milk or new cheefe, when beginning to crumble to peices. Thefe four little inteftines are full twice as long as the real guts of the creature, and they form a great many uncommon turnings and windings in the thorax and abdomen, fo that it requires no fmall pains and attention to difcover and feparate them. In the next place are the large inteftines, which here and there fwell out into nodules, as it were, and are filled with clay, red particles of ftone, grains of fand of different fizes, and other fimilar fubftances. All thefe particulars will appear to greater advantage in the figure which I propofe to give of the Nymph's inteftines, accompanied

with

with a defcription of the nature of the fand or gravel which are found in thofe parts.

The falival veffels, Tab. XXXIX. Fig. VII. *a.* are two channels, clofed at their ends. They are of a membranaceous tranfparent fubftance, and are feated in the thorax, where they make a great many windings and turnings. In colour they refemble frefh curds, on account of their contents which appear through them; and accordingly, on their being cut, nothing freely flows from them, the matter they contain being quite coagulated. The falival veffels unite at laft, fo as to form only one, *b*, which terminates at the mouth, to which it is inferted upon in the back part of it. Near this infertion appear two fmall particles, *c c*, which very much refemble little mufcles. As I never met with any fluid matter in the veffels I have been laft defcribing, I cannot take upon me to fay any thing pofitively, concerning the ufe which the Worm may make of them, though I called them falival veffelves, becaufe fuch channels are very remarkable in other Worms, and alfo in fnails. They appear even in the Nymph of the Worm now before us, and afterwards in the Fly, in which they are ftretched out to their full length, and after pervading the thorax, they terminate in the abdomen, being remarkably broad at their extremities, if compared with their condition, as they were in the original Worms; this makes me believe, that thefe veffels do really, at laft, perform in the Fly, the office of falival ducts. The mouth, Fig. VII. *d*, at the bottom of which thofe falival ducts terminate, is here reprefented without the eyes, becaufe, in diffecting this Worm, both the eyes, and thofe parts which conftitute the fides of the head, very eafily feparate from the mouth.

There is no part of this Worm without its pulmonary tubes *. They confift of two very confpicuous and confiderable tubes, Tab. XL. Fig. I. *a a*, which are compofed, as it were, of flattifh rings, and are much wider in the middle than at the back or fore extremity, which runs towards the tail. Thefe tubes are feated on the fides of the infect's body, where they unite with the puncta refpiratoria, or breathing holes. It is probable, however, that the infect does not make ufe of them for breathing, till it is arrived at the Fly-ftate, when it lives in the air; fo that thefe channels remain clofed, till the infect comes to live in another manner, juft as the afpera arteria of a fœtus continues clofed, as long as it lies in the amnion, and furrounding waters. The pulmonary tubes are diftributed all over the body; they even penetrate the bowels, brains and nerves, in order to fupply every part with this vivifying fluid. Great multitudes of them are to be feen in the fame place with the optic nerves, and the increafing membranes of the eyes, *b*, and they gradually enlarge, in order to contribute to the formation of eyes in the Nymph, and afterwards anfwer all the purpofes of fuch parts in the Fly. Here and there thefe tubes meet, and unite together from the parts, *c c*, efpecially about the fides of the body, *d d d d d d*, where one may perceive a general anaftomofis of them one with another, by means of their common intermediate branches, ftretching from one breathing hole to another; from hence fpring an infinite number of ramifications, adminiftering to the membranes and mufcles of the fkin, which I here mark with points, *e e e e*, and likewife to the internal parts. At laft, the principal channels end at the feet, *f*, by two diftinct tubes opening into one paffage, where they ferve to take in air for the creature's ufe, and alternately expel it, as has been already fhewn in the external furvey of that part, as the faid tubes appear very plainly through the tranfparent fkin of the infect.

The largeft of thefe pulmonary tubes are fufficiently confpicuous; and they are compofed of crooked rings, and are alfo fomewhat flat, as I already mentioned, Tab. XL. Fig. II. *a a.* On ftretching a piece of thefe tubes, thofe rings which compofe them, feparate very readily, fo as to roll out to the length of two or three fpans, and then they look very pretty, being like an extended fcrew, or an untwifted fpiral, or a filver wire that had been wound up upon a needle, *b.* This filver-like thread, of which the rings are formed, is almoft as ftrong as the thread fpun by the Silkworm, on breaking, it fnaps with a crack that is very perceptible.

The fat, Fig. III. *a*, is diftributed all over the Worm's body, fo as to be met with in the head, as well as in the abdomen and thorax. It is as white as the pureft fnow, except at the tail, where it generally inclines to be a little green. As to its textute, I don't well know how to defcribe it, on account of the ftrange variety, in point of configuration of the particles that compofe it; for they are round, *b*, oblong, *c*, broad, *d*, angular, *e*, pyriform, or in the fhape of a pear, *f*, and of almoft every other imaginable fhape. This fat is moft firmly united with the pulmonary tubes that run through it, *g*; fo that I believe it ferves, in the fame manner with the Omentum or Cawl in man, to bind together the blood-veffels, and convey them in fafety to their feveral deftinations. This fat, if laid on a piece of glafs, and held to a candle, melts like oil, and immediately flames; this proves, that it is really what I have called it. Thefe particles, in regard to the veffels contained in them, might be called vafa adipofa, or fat veffels; but fuch a name would be improper for them. This fat in the Nymph and Fly, retains nothing of its original form, as may be feen by examining it in the Worm where it exhibits fo entertaining a fight, that it is impoffible for words to give a juft idea of it.

Not only the form of the heart, Fig. IV. *a.* in this Worm, but its pulfations alfo may be feen through the fkin, under the third ring, counting from the head; but this is a great deal more perceptible in the Nymph, when

* The number of thefe pulmonary veffels in the generality of infects is aftonifhing, and it is fo alfo in plants. They not only appear confpicuous in all parts of them, but the greater part of the ftalk in May is compofed of them; this is particularly obfervable in the ftalks of bulbous plants: and in the fame manner we fee it in the infect-tribe moft plain, and the tubes moft numerous, and divided in the fofteft fpecies.

ſtripped of its outer covering; for at that time the motion of the heart appeared to me ſo plain, and was withal ſo conſiderable, that I ſaw it diſplace a particle of fat in one of its vibrations. The end of this powerful organ, when it is faſtened to the tail, is a little ſharp and narrow, but here and there it dilates itſelf, Tab. XL. Fig. IV. *aa.* Towards the head it gradually widens *bb*, and then cloſes again into a narrow channel *c*, in which form, after paſſing through the abdomen and thorax, it purſues its courſe towards the head, where it is intimately united with the membranes of the brain. Thus, in regard of figure, the heart of this Worm nearly repreſents the Worm itſelf, except the part next the head, being a great deal narrower, and that next the tail, dilating itſelf here and there, as in Silkworms.

On opening either the Worm or Nymph, the motion of the heart preſently ceaſes; and if it did not, the particles of fat with which it is ſurrounded, would hinder us from ſeeing it. For this reaſon, the beſt time for examining the heart of this inſect, is when it has attained the Fly-ſtate: or if we chooſe to do it in the Worm, we ought firſt to leave it for ſome time in ſpirit of wine, that the fat may gradually diſſolve and waſte away; but at this time, the heart is ſo delicate as not to ſuffer any air to get into it. In the beginning, I really thought I ſhould never be able to diſcover or diſcloſe this part; and I muſt own, that human ignorance and weakneſs never appeared ſo evident to me, as during my ſurvey of this little inſect; for with all my attention and diligence, I found it impoſſible to examine it as minutely as I propoſed, tho' I ſpared no time to get the better of all the difficulties that oppoſed my inquiry; the wonders I diſcovered in it, being but a ſmall part of thoſe accumulated miracles I have here related. This my inſufficiency has made me very often, in the courſe of my inquiries, break out within myſelf into the following words:--- O God, thy works infinitely ſurpaſs the reach of our feeble underſtandings; all that we actually know of them, or ever can know, is but a faint and lifeleſs ſhadow of thy adorable perfections. The brighteſt underſtandings fail in the contemplation of them, and are obliged to confeſs, that all this boaſted penetration is but ſhort-ſightedneſs, when employed in fathoming the depths of that power, goodneſs, and wiſdom it has pleaſed thee to exert in the loweſt parts of thy creation!

The truth of theſe words evidently appears by the conſtruction of the brain, ſpinal marrow, and nerves of the Worm here under conſideration, which I am now going to deſcribe; for this conſtruction is ſo wonderful, that I doubt very much, whether any thing equal to it was ever before obſerved in any animal. The brain conſiſts of two globular lobes, Tab. XL. Fig. V. *aa.* Theſe lie upon the gullet; and for this purpoſe nature has contrived a ſlit *b* in the ſpinal marrow for the gullet to paſs through. On the forepart of the head appear the membranaceous parts of the eyes *cc*, which gradually expand themſelves along with the optic nerves that are to ſerve the ſucceeding Fly, and grow till they are arrived at their juſt period of increaſe. In the mean time, theſe membranaceous rudiments of the Fly's eyes are curled and folded up, and cannot be ſeen but very imperfectly, becauſe the inſect has not as yet attained its Nymph-ſtate, in which at laſt all theſe parts unfold themſelves, and become very diſcernible.

The ſpinal marrow conſiſts of eleven nodules *dd*, which form the moſt elegant ſpectacle that nature ever exhibited; for it is bent ſo as to reſemble a ſwine's tail, and runs as it were in curls from one end to another. This curling may be ſtill conſiderably increaſed by cutting the nerves. The figure I give of this part does not expreſs all the windings of the original, the better to exhibit the eleven nodules, from whence all the other nerves take their riſe; for all the nerves of the inſect ariſe from the brain, the ſpinal marrow, and theſe nodules. In the firſt place we are to name thoſe nerves which tend to the forepart of the head, and running under the membranaceous rudiments of the future eyes *ee*, are diſtributed to the gullet, the jaws, the mouth, and palate, to the Worm's eyes, the muſcles of the legs, and parts thereabouts. Next are the nerves *f* which extend to the ſides of the inſect's body. Laſtly, there appears a conſiderable number of them *gg*, that ſpring on each ſide from the eleven nodules of the ſpinal marrow. To avoid confuſion, I have omitted ſome of them in the figure; the laſt mentioned ramificatiens go to the ſtomach, inteſtines, muſcles of the ſkin, and all the other internal parts, which they ſupply with motion, ſenſe, and life. But how is it poſſible to deſcribe the ſpirits contained in thoſe nerves, and the manner in which the ſecretion of ſuch ſpirits is performed? For my part, I freely acknowledge, that as yet I have not been able to diſcover for what purpoſe the medulla ſpinalis is curled up in this inſect, while a Worm, in ſo ſtrange, but elegant a manner;* whereas in the Nymph, and afterwards in the Fly, though neither of them are ſo long as the original Worm, it appears ſtretched out to its full length. It is in the eleven nodules that the alteration is moſt conſiderable, for theſe in the Nymph and Fly (O incomprehenſible wonder!) are found at a greater diſtance from each other, than they were in the Worm. The nerves, on the contrary, from lying at full length in the Worm, are curled up and folded in the Nymph and Fly, and are otherwiſe altered in a moſt ſurpriſing manner, as I ſhall hereafter explain by a figure of the Fly's ſpinal marrow. The tranſmutation, there-

* As important as the ſpinal marrow is to the animal œconomy, we find that it does not obſerve the ſame courſe in all creatures. In the generality of animals it runs through the middle of the back-bone; but in fiſhes in general, it is carried through certain peculiar apophyſes ſituated on the upper part of the vertebræ: we ſee in how ſtrange a manner it is diſpoſed in inſects. There cannot be a better ſubject of inquiry for the naturaliſts, than into the reaſons of this various cauſe, and the purpoſes it anſwers.

fore,

fore, from a Worm to a Fly, obfervable in this infect, prefents us with a real miracle, and may juftly be confidered as a laying down of old worn-out parts, and an acquifition of new perfect ones inftead of them: in fine, as a total change of an old to a new, and of an imperfect to a perfect body, infinitely furpaffing the utmoft ftretch of human underftanding, as on reading and attentively confidering the hiftory now before us plainly appears. As for my part, I dare boldly affirm, that the incomprehenfible greatnefs of the Deity manifefts itfelf in thefe myfterious operations in a particular manner, and affords us an opportunity of examining, as it were, with our fenfes, the Divine nature.

If thofe authors, who invented a metamorphofis, in order to folve the difficulties that occur in the hiftory of infects, had feen the wonders I have been juft relating, it is probable, that they would have made arguments of them to fupport their erroneous opinions; tho' the infect itfelf, notwithftanding all its changes, conftantly continues one and the fame, and like a chicken, attains to a greater perfection, by a mere gradual increafe of its parts, and no otherwife; for even the parts themfelves always remain the fame, whatever alterations we may obferve in their figure. What I here affirm of the parts, holds true even at the time when they fall off or difappear, in order to make room for others which fprout out to fupply their places.

Job, in like manner, fpeaking of the refurrection of his body, fays, "with thefe eyes I "fhall fee God."

Neverthelefs, I fhould be forry, that any one were weak enough to imagine, that thefe our mortal eyes, which are but duft and afhes, and as fuch are condemned to putrefaction and decay, are ever to appear in the fight of God. By no means; the body we now carry, is but the feed or egg, as it were, in which another more noble body lies concealed; and of this myftery the Worm we are treating of affords a moft fatisfactory example; as it might very juftly fpeak of its eyes, as it were, in the following manner: With thefe, my eyes, I fhall raife myfelf on high, foar up to the fkies, look down upon the fields, and dart with rapidity through the air, in praife of my maker. Thus, I fay, this Worm might boaft of its eyes in words, which however are far from being true, except in refpect of that perfection which the eyes are afterwards to attain; on the infect's changing to a Fly; for then they are to be increafed in number, otherwife ennobled, and fhall enjoy a fight more perfect than the former, as I have already fufficiently demonftrated in the eyes of bees.

The moft confiderable mufcles of the Worm here treated of, are in general placed in the head: of them I have defcribed and delineated only thofe which ferve to move the feet. Moreover, in the thorax alfo, the belly and tail, are feen a great number of mufcles, which being extended from one of the annular incifions to another, move the body various ways, by means of fibres formed and difpofed in a variety of manners. But as thefe mufcles do not remarkably differ from thofe which I have defcribed in other infects, and which have been reprefented in the preceding figures, I need fay nothing of them farther, until I come to the Fly itfelf. I fhall therefore clofe here the prefent chapter; adding only, that the limbs are fometimes diftorted in this Worm; fo that its body is found really crooked and bent: and hence we are taught, that thefe infects are liable to the fame calamities that other animals are fubject to by the law of nature. It is, however, worthy of notice, that when I viewed a diftorted or deformed Worm, of this fpecies, when changed into a Fly, it was no way deformed; its body being then perfect after its change, or rather its refurrection.

CHAP. IV.

The wonderful manner wherein this Worm paffes into a Nymph; and of the parts that are feen in the Worm, when it is ftript of its fkin; and the fame parts afterwards clearly fhewn in the Nymph.

THE Worms here defcribed, are at length changed into Nymphs of the fourth order, when their limbs and other parts are fufficiently grown under the fkin. When they are about to change, they betake themfelves to the herbs that float on the furface of the water, and creep gently thereon; until at length they lie at reft, partly on the dry furface, and partly on the water: if they are about that time driven off into the water by force of the wind, or if they be kept in a little veffel filled with water only, yet their change is not on that account impeded. But when they afterwards, under the form of a Fly, iffue out of the habit of a Nymph, then indeed they are very eafily fuffocated in the water; as long as thefe little infects are Worms, they can conveniently live in water, but by no means when they are changed into Flies. Indeed, man alfo, whilft in the uterus, lives in the water of the amnion; but he can by no means do this afterwards, when, by breaking open the membranes, he is brought into the world. Therefore thefe Worms, lying in their natural fituation, always feek after the floating herbs, wherein at length they lie at reft; and then they, by degrees, contract themfelves, and in a manner fcarce perceivable, lofe all power of moving.

Then

Then the inward parts of the Worm's tail insensibly separate from the outmoſt ſkin, and become greatly contracted: and this perhaps does not happen without pain to the creature: for this external ſkin is then commonly gathered into three, and ſometimes into four windings, Tab. XLI. Fig. I. *a a a*, and its extremity is left like an empty ſpace, into which the air penetrates, and ſoon fills the place which the body had before occupied, but has now left vacant by contracting itſelf. If this void ſpace be not filled up by the ſucceeding air, the ſkin of the tail becomes curled into itſelf: but this I obſerved only once.

Thus this inſect is by degrees changed within its own ſkin, nor does it before this time caſt it, or is it outwardly altered into a conſpicuous Nymph; ſo that this order of tranſmutations is entirely different from that obſerved in ſilk Worms, and other innumerable ſpecies of inſects.

I have often ſeen this Worm, in the ſpace of twelve hours, that is from ſix in the evening to ſeven in the morning changed, into a Nymph. And all theſe things are performed in a hidden, obſcure, and unknown manner, inwardly within the ſkin, which lock them up, as it were, from our view. For this reaſon, this ſpecies of metamorphoſis has been tortured, as a thing ſo monſtrous and incomprehenſible by thoſe, who, like the dog in Egypt, look only in a ſlight aud curſory manner into nature *.

When the Worm, which is thus to be changed, has a ſoft ſkin; that ſkin neceſſarily accommodates itſelf to the changes and contractions of the internal and inviſible body of the Nymph. And hence it happened, that even the moſt learned, who have wrote on this ſubject, have not ſcrupled to give theſe inſects the name of eggs: in which indeed they have committed a very great error, and corrupted the natural miracles and truths of God. Thus they think and inſert, that one inſect is changed in this inſtance into another; nay, that it again becomes an egg; and that the egg is afterwards changed into a Fly, by a raſhly imagined abſolute metamorphoſis: others add, that all theſe things are produced by chance, and from putrefaction: and this indeed is the ſhort path to atheiſm. For, if the generations of things be ſo ſubject to chance, what prevents man from being thus as eaſily produced in the ſame manner? This alſo ſome have not ſcrupled to declare in their writings. God is certainly as admirable in the ſtructure of inſects, as in that of man. The body of a beaſt deſerves as great admiration as the human body, if we conſider both in their kind and nature. Both far ſurpaſs the ſphere of our inquiry: both are incomprehenſible and impenetrable; ſince innumerable divine miracles are contained therein.

Whilſt this Worm therefore is changing within its ſkin, the body, head and tail inſenſibly ſeparate from the outmoſt inveſting ſkin. The legs alſo about that time, and their cartilaginous bones, are, by reaſon of the joints, drawn back from them, left intirely empty within; and hence they are drawn backward or inward to the orifice of the mouth, and there they lie unmoved. The Worm at that time alſo loſes all its ſkull, and the beak, together with the horny bones belonging thereto; for all theſe remain fixed in the ſkin of the head. From thence it afterwards draws its horns, its trunk, and other parts, which are there inwardly increaſed, and are afterwards to be ſeen in the Nymph.

A matter worthy of great notice here, is this: the optic nerves ſeparate alſo from the eyes, and no more perform their former office. The muſcles of the rings alſo in like manner, and a great part of the pulmonary points of reſpiration are ſeparated from the external ſkin. Thus the whole body contracts itſelf by degrees, into a ſmall compact maſs.

But the greateſt change is obſerved in the hinder part about the tail: for there the body, having quitted, Tab. XLI. Fig. *b*, *c*, *d*, its three extreme rings together, riſes up into the fourth, *e*, and ſometimes even to the fifth ring. Therefore, if you view, in the light, the Worm, which hath been for ſome time changed; you will very diſtinctly, and without the aid of diſſection perceive, that its hindmoſt rings are empty, or are only filled with air: this is likewiſe, though more obſcurely, obſerved between the head, and the ſecond ring *f*. But the place which the Nymph, encloſed within poſſeſſes, then appears black, *g*; becauſe it does not tranſmit a ſufficient quantity of the rays of light.

At this time the gullet too, the inteſtines, and the pulmonary tubes in a manner caſt a coat within the ſkin: this indeed is alſo very ſingular, and amazingly ſhews the miracles of God; teaching at the ſame time, how the former body is entirely caſt off and renewed. In order to make this evident, it is neceſſary to open the ſkin of the abdomen: after this the Nymph, Fig. II. *a*, and its parts, together with the caſt, pulmonary pipes, *b b*, will manifeſtly preſent themſelves to view: nay, it will likewiſe be ſeen, how the Worm hath caſt off, *c*, all the parts of its head and beak, and is became entirely immoveable, except in the tail; by means of which it ſtrongly moves, agitates, and draws itſelf back even to the fifth ring of the body.

The whole Aſpera arteria about that time caſts its ſkin on each ſide. For, as this conſiſts of two remarkable tubes; therefore they are firſt turned out of the body, whilſt the Worm is contracting its tail, and are left ſticking in the empty ſkin, as I ſhall more clearly deſcribe, when I come to explain the method whereby the Worm, when changed into a Fly, breaks forth out of its ſkin; for it then draws the exuviæ from the other pulmonary pipes.

* The hardneſs of the exterior ſkin, in this and many of the other Worms which change into Nymphs, under a covering of their own outer ſkin, which forms a kind of ſhell, makes it appear ſtrange, that ſo feeble a creature as the young Fly can get out. But nature has provided for this. There is always a weak part of this ſhell, where the head of the Fly lies: there are certain ſutures, at which it may eaſily be burſt open: and the means ordained for theſe, are the ſwelling and ſubſiding of the creature's head. This becomes inflated like a blown bladder, and then ſhrinks down again at repeated intervals; and theſe motions burſt the ſhell.

In order to place thefe truths the more evidently before our eyes, we muft very cautioufly draw the Worm out of its fkin, at the time when it begins to harden or grow ftiff; for, fince this Worm is not yet in reality become a Nymph, but has all its parts difpofed in a different manner than in the Nymph; we may fee each of them in its place, and where they are refpectively fituated in this ftate in the head and tail. Thus I exhibit, Tab. XLI. Fig. III. *a a*, the antennæ or horns, the head, *b*, which I have delineated fomewhat too large; under the latter is feen the probofcis or trunk, and on each fide the firft pair of legs, *c c*; beneath thefe appear the wings, *d d*, and then the fecond, *e e*, and third pair *f f* of legs. Then follows the abdomen, *g*, with its rings, and then the tail, *h*. In the abdomen are very diftinctly feen tranfparent particles of fat; and in the tail, the pulmonary tubes come in view, difplaying, or rolling out themfelves, *i i*. It further appears how even the inteftines, *k*, caft a fkin; for they remain fixed to the orifice of the fundament, which opens in the utmoft part, and is here cut off from the feparated fkin, *l*; for the Worm does not difcharge its excrements through the extremity of the tail, but fomewhat higher, where we may likewife fee the fundament.

What I have hitherto advanced, may be feen more evidently in the Nymph; in which thefe parts are difpofed in their natural order, and ranged beautifully and artificially among themfelves. Here then occur the antennæ, Fig. IV. *a a*, with their joints: the eyes, *b b*, which are now arrived at their full fize: the probofcis, *c*, and its appendages, fituated under the eyes on the breaft: the firft pair of legs beautifully folded, *d d*; behind thefe are likewife feen another pair, *e e*: under the latter, again appear the wings, and their artificial convolutions and beautiful foldings, *f f*. The body likewife exhibits its annular divifions to view, *g*. Under the fecond pair of legs, the third pair likewife exhibits itfelf, *h*. Thofe black fpots alfo that are feen on the body, and which we fhew to be fituated in the Worm, above or over the points; the pulmonary pipes, are here likewife very diftinct *i i*. But near them are alfo prefented to our view four apertures of the pulmonary tubes, *k k k k*, and alfo the annular inflexions of the body, with fome fmall prominences, there ftanding above the furface of the body, which have alfo caft their fkin. The claws are tranfparent in the extremities of the feet; and make a beautiful figure, when the Nymph, being fome days old, has loft the greateft part of the fuperfluous humours by evaporation, and in the integuments or covers of the membrane, wherein it is invefted, and in its outmoft fkin in which it is involved, like a tender birth newly brought to light, becomes by degrees ftronger and more firm; fo that at length it is able to creep abroad, and break open and caft off both its coats at the fame time: that is, this Nymph is covered with two integuments; whereof the interior is a thin membrane, which very clofely invefts the Nymph: the other, or exterior, is conftituted by the outmoft hard fkin, within which the little infect has performed its change in an invifible manner. This is the fkin which makes this infect look like a Worm at this time; and it is this fame fkin which made me give this order of changes, the name of a Vermiform-Nymph.

Whoever therefore defires to have a thorough knowledge of thefe creatures, muft treat them in all thefe ways. I have obferved, that in thofe Worms, which I had newly drawn out of the fkin, one might diftinguifh plainly the mouth and the points of refpiration; even more clearly than in the Worm that is ftill, creeping, fwimming, and is no way changed. Indeed, had I not refolved to be fuccinct in this place, I fhould defcribe what has been hitherto faid much more at large, and fhould have delineated all the parts, and at the fame fhewn their fituation in the Worm; as alfo what pellucid little parts are obfervable therein, what their ftructure is, their motion, how the pulmonary tubes are inferted, and much more; but I am obliged to be fparing of my leifure hours.

CHAP. V.

The anatomy of the Nymph, the fat, the pulmonary tubes, the ftomach and inteftines: the wonderful changes obfervable in the ovary, mufcles, fpinal marrow, and other internal parts which infenfibly come in fight.

THE Nymph I examined being frefh ftript of its integuments, was of a bright green colour, with white tranfparent, and fome greenifh particles of fat: and indeed it made a beautiful appearance; efpecially as the pulmonary tubes were at the fame time obferved to glitter like pearls. The head, the legs and wings were foft and fluid like water, and when but very lightly touched, they immediately difcharged an aqueous humour. The pulmonary tubes had become confiderably fmaller, narrower and more contracted. From the tail unto the place, next below the wings, I counted feven apertures of the lungs; all which, as well as the rings of the body being clofely gathered up above each other, differed very much from the points of refpiration in the Worm; fo that therefore the Nymph was now only one third as big as the Worm had appeared to be before.

If this Nymph be laid on its belly, the heart is immediately feen beating in its back, without any previous diffection: this indeed appears very rarely fo after the incifion of the skin; becaufe the heart then, by reafon of the gufhing out of the blood, which is aqueous, and like an ichor, prefently ceafes its palpitation. Immediately

ately under the ſkin are ſeen alſo the muſcles appointed for moving the rings of the abdomen. The next thing that comes in ſight is the fat: this was not much changed here; but, upon viewing it in a more adult Nymph, I found it ſo wonderfully altered, diminiſhed, and extenuated, that I thought I ſaw not fat, but a parcel of eggs: that is, its former oblong, angulated, broad particles, were now become almoſt round and globular, Tab. XLI. Fig. v. *a*. Beſides, alſo, it loſt ſo much by the evaporation, and contracted itſelf in ſuch a manner, that its diminution indeed was very conſiderable. Hence it muſt neceſſarily follow, that the body, on account of the great plenty of the waſted fat, muſt become more contracted, and poſſeſs a ſmaller ſpace than before. The colour of this fat inclined to purple; but in the hinder part of the belly it was entirely green. Thoſe particles of fat adhered to each other, and alſo to the pulmonary pipes, *b b*; ſo that, when I touched them with a fine ſharp-pointed knife, made like a lancet, they parted from each other with the leaſt motion. In the Nymph that was very newly changed, the fat became more green.

In the ſtomach and inteſtines alſo is obſerved a very great and wonderful change. This, however, is more or leſs obſervable, in proportion to the quantity of the Nymph's ſuperfluous fluids which have exhaled, and as the internal humours have been more or leſs diſſipated. Hence it cannot, indeed, be deſcribed how much the inteſtines are, by reaſon of their habit and figure, altered, dilated, or contracted; that is, according as the ſuperfluous moiſture is more or leſs expelled by perſpiration. Among all the remarkable changes which I have obſerved in theſe parts, I ſhall exhibit that which, in my opinion, is the moſt beautiful, and ſhall begin a deſcription of it from the gullet, Tab. XLI. Fig. VI. *a*. The gullet is here obſerved to be placed out of the horny parts of the head, *b*, back, and contracted legs. It appears alſo how this gullet paſſes *c* through the aperture of the ſpinal marrow, under the brain, and extends itſelf *d* unto the ſtomach. The ſuperior or upper part of the ſtomach is alſo found to be contracted, as it were, into five annular ſmall rugæ, or folds, through which the pulmonary tubes run very beautifully: and hence, on account of that contraction, it cannot be there ſeen how the ſtomach is circumſtanced on the inſide. A little lower, it exhibits quite another face; for it is divided by oblong grooves or furrows, which, in the figure, I have marked *e* with points. But as the ſtomach is there likewiſe inflated, and filled with a limpid humour, it is therefore obſerved *f* to be like an open tranſparent tube in this part; and it is the more conſpicuous, as it is in colour ſomewhat red. But it is neceſſary to obſerve, that the part of the ſtomach, juſt now deſcribed, eaſily ſeparates from the next inteſtine. The beginning of this ſmall inteſtine is very beautifully ſinuated, or bent, in like manner as the ſuperior or upper part of the ſtomach, with ſix foldings, or, as it were, corrugated convolutions, *g*. Afterwards, within this inteſtine, is diſcovered another ſmaller inteſtine, *h*, which, being contained in its cavity, and curled with many windings, wonderfully twiſted, deſcends, *ii*, and again terminates underneath, in an open extremity.

This little inteſtine is of a bright yellow colour, and appears very plainly through the larger inteſtine; becauſe the fluid, which is in that part of this inteſtine that comprehends it, is limpid and perſpicuous. If that ſmall inteſtine be wounded, the little inteſtine, contained in it, may be drawn out almoſt twice as large as it appeared in the cavity of the larger. Then it is manifeſt, that the yellow colour, wherewith its ſurface is diſtinguiſhed, proceeds from the yellow fluid contained in it. What the uſe of this little inteſtine is, is impoſſible for me to explain: in this reſpect, the works of God are impenetrable. Nor ſhall I, indeed, ſcruple to aſſert here, that not even one truth, in reſpect to the actions of the parts of animals, or even of the human body, is hitherto fully and clearly known to us. Indeed, thoſe who think the contrary, acquieſce in imaginations, taking them for facts. From my own obſervations I ſhall here add one thing, that is, that I have found this little inteſtine in the gut of the Worm now preparing to undergo a change: and this is the reaſon which induced me to attempt delineating the head of the Worm to the gullet, though I there repreſent the parts of the Nymph. I once found that inward little inteſtine in an old Nymph: it was there very brittle, and at the ſame time ſomewhat more red, and in a condition as if it began to waſte away. And hence it likewiſe ſeems evident, why I have not afterwards found it in the Fly. Indeed, in thoſe Flies, which are very juſt excluded, I have ſeen that this little inteſtine has been abſolutely conſumed. Wherefore one may probably conceive, that this little inteſtine is the inward coat of the ſmall inteſtine in the Worm; and that this coat, not being caſt out whole and entire, is by degrees conſumed in the body. But theſe are only my own conjectures. I remember I have ſeen ſuch little parts in Spiders too. I likewiſe find, that Thomas Willis, that celebrated member of the Britiſh Society, obſerved one inteſtine in another in the Earth-Worms. And ſince I here treat of the inteſtines, I cannot help taking this opportunity of complaining of the ingratitude of Caſparus Bartholinus, junior, towards me: for he, though I had, out of good-nature, ſhewn him all the more uncommon preparations and ſpecimens, which I had procured by the help of different anatomical contrivances; yet, in revenge that he did not ſo far ſucceed as to make me communicate the ſeveral methods to him, and being full of indignation, he has not ſcrupled to object to my propoſition, whereby I affirmed that I would ſometime reſtore the certainty of the office of ſanguification to the liver. With what eyes has this lyncæan author, who, in the front of his book, aſſumes the bombaſt title, *Aut Cæſar, aut nihil*, i. e. a man, or a mouſe, diſcovered my thoughts ſo far as to know, that I had only one experiment for this purpoſe? Indeed, my anatomical preparations, which he ſo much admired, could and ought ſufficiently to have taught him, that I have not advanced that theſis raſhly, or without important experiments. I would therefore adviſe him to contain himſelf yet, and temper his gall with water, until I have leiſure, and a more convenient opportunity, to treat this ſubject, and ſolve the ſeveral doubts which I have ſaid hitherto occurred to me. I ſhall then ſhew the experiments, and aſſign the reaſons, which confirm me in this opinion. And theſe are the very words, wherein I propoſed to the public the ſaid theſis, in my notes on the Prodromus of the famous Hornius. But he that is bent on revenge, has in view only the monſtrous images of his own thoughts. In the mean time, however, as I have there mentioned experiments and reaſons, this raſh young man might have concluded from thence, that I was provided with more experiments, to demonſtrate this theſis, than that trifling one, which I really do not acknowledge to be mine, in the place above cited. Nay, I join with this good-natured Bartholinus, who, like a Butterfly, has yet ſcarce crept out of his Chryſalis, that the experiment, conſidered by itſelf, contributes nothing to ſtrengthen my theſis: ſo that it therefore appears, that he would refute what he himſelf does not underſtand, and perhaps is not capable of underſtanding. But I return to my hiſtory, which I hope will be more uſeful than a controverſy of this nature. In treating this ſubject hereafter, I ſhall only explain what is pertinent to the matter itſelf, leaving altercations to thoſe who love them.

Below the place where the little inteſtine, before deſcribed, is ſeen within the inteſtine of the Worm, the ſmall gut is again diſtended, equal, ſmooth, and moderately large; but then a kind of ſmall tube, Tab. XLI. Fig. VI. *k*, is inſerted therein, which is divided into veſſels, either vaſa varicoſa, or rather the cæca, or cloſed guts. Theſe veſſels, like ſo many ſmall inteſtines, diſcharge themſelves into the beginning of the great guts, where the latter are united with this dilatation of the ſmall. Theſe blind or cloſed guts are of a wonderfully elegant conſtruction, and two of them are found commonly filled with a whitiſh humour; which in the more adult Nymph, I obſerve, is by degrees ſent alſo to the great guts.

This ſubſtance is ſometimes beautifully divided, as it were, into knots; and is likewiſe inwardly ſeparated, *mm*, by a more limpid ſubſtance, which ſeems mixed among it, like whey; that nothing can ſcarce be exhibited to the eye more artificially and beautifully diſpoſed, or more conſpicuous. The figure, I have given, exhibits only a ſmall part of this elegance, and that is but rudely drawn or delineated; becauſe, to expreſs it accurately, there would be need of a much larger figure. Theſe cloſed veſſels cannot, but with very great difficulty, be ſeparated from the fat that is annexed to them; and this difficulty is the greater, becauſe that white ſubſtance is not found in every part of them. Hence it is, that they are very eaſily broken. But this happens ſtill eaſier in the Worm, becauſe the blind veſſels are more ſtrongly connected in it; ſo that it requires more labour to diſcover them there. They diſperſe themſelves, *nn*, with various and wonderful windings and convolutions, through the whole belly; for they are ſeen no more in the thorax of the Nymph, which is all filled up there with the muſcles of the legs, and other parts. We at length obſerve, that the two ſuperior or uppermoſt of theſe inteſtines unite, *o*; and one of them is likewiſe divided twice on the inſide, and twiſted into admirable windings, *pp*: this goes towards the great gut, into which it diſcharges its contents. The other lower pair, wherein the above mentioned diviſion of the white ſubſtance is expreſſed, *mm*, are likewiſe twiſted into various windings, *qq*, and at length terminate *r* in the cloſed tube. The fourth of theſe inteſtines is circumſtanced in the ſame manner, *ss*; for after various convolutions, it terminates at laſt alſo in the blind annular duct, *t*.

The colon is alſo every where uneven, with many knotty dilatations, *u*. Theſe are produced by the white ſubſtance found in its cavity, whilſt the little inteſtine hath been contracting itſelf in thoſe parts, where it contains a leſs quantity of that ſubſtance. A little lower is ſeen a larger knot *x* in this inteſtine, filled with a black ſubſtance. And at length two more dilatations occur *yy* in it, which poſſeſs thoſe places of the inteſtine, which, by the help of the humours that flow into them, ſwell into very large bags. But as the little inſect, after putting on the form of a Fly, ſecretes and diſcharges that colluvies of humours; hence theſe windings may be properly called the cloaca, or ſewer. Laſtly, one may ſee the rectum, or ſtraight gut; and underneath, in the tail, the podex, or orifice through which the inteſtines diſcharge themſelves, *z*, in the laſt ring of the abdomen. I have alſo judged it proper to delineate this ring, as it coheres with the anus, in order to repreſent more clearly all the things which I have mentioned.

When the Nymph is older, I have ſometimes found its ſtomach filled with a green fluid: but when it approaches to the change of its ſkin, in order to acquire in a ſhort time the form of a Fly, its ſtomach and inteſtines are found ſo conſiderably contracted, and by degrees become ſo much ſhorter, that one would affirm one had diſſected another animal, unleſs one had obſerved all theſe changes, according as they gently ſucceed each other from the beginning.

In the lower region of the belly the cæcum and rectum, or blind and ſtraight guts, are expanded at that time very wide; and are found to be ſwollen, glittering, and ſmooth, on account of the white moiſtures or humours which are mixed with a chalky matter. Theſe humours,

mours, flowing out of the wounded cloaca, or liver, render every thing muddy; and, when thrown into the water, they likewife foul and deftroy its clearnefs.

The double ovary *, which appears of a whitifh aqueous colour in the young Nymph, is, in the more advanced ftate, of a pale yellow colour. But if the Nymph is to change its fkin immediately, it appears to be a beautiful green. In the region of the abdomen, where the ovary extends itfelf to the thorax, are feen two empty curled bags. They are the two pneumatic veficles, as I fhall fhew more at large in the hiftory of the parts of the perfect Fly. In the extremity of the body, between the laft rings, appear three very beautiful tranfparent knots; each of which, being fupported by its own footftalk, cafts a fkin, and difclofes itfelf, when wounded. What thefe little parts are, I cannot determine: I have difcovered only, that they belong to the genital organs of the female; for I never faw them in the males, and therefore I fhall delineate them in the figure of the latter.

The male part, at the fame period of maturity, became by degrees confpicuous; and, from a thin aqueous humour, having acquired fufficient firmnefs, they had obtained a limpid and pellucid whitenefs. The mufcles in the breaft are at this time much more compact, and, from a pale white, become of a purplifh colour. In the young Nymph they were foft, mucous, and like veal-jelly, and had no firmnefs.

But much more remarkable than thefe are thofe changes, which, by a flow accretion of parts, are feen in the head, eyes, pulmonary tubes, and fat, which may be feen there in a very abundant quantity; and alfo in the horny little bones, which firft confifted only of humours, as it were, and membranes. But I now pafs thefe things by, without further notice, becaufe I fhall hereafter make mention of fome of them in the Fly itfelf. Above the brain are fituated two white, foft, little parts, fomewhat like knots, which rife like two horns: they are annexed to the fides of the thorax, and reft on the ftomach, as on a bafis or foundation. But what thefe little parts are, as alfo their ufe, I am likewife hitherto ignorant.

I afterwards likewife obferved in a Nymph, which I found dead in its fkin, that the purple fat was there variegated with white fpots. The little inteftine, which I before defcribed to be contained within one of the inteftines, lay loofe therein, without adhering any where, and was curled; but that part of the inteftine, which enclofed it, feemed to be very confiderably dilated. The uvea of the eyes was of a very beautiful bright purple. Here and there, in the abdomen, were feveral fmall Worms; fome of which were already changed into Nymphs, and appeared to me as if they were to be transformed into Flies very foon. It would require a large treatife to defcribe how fuch things are produced in the bodies of other infects, and what ftrange and unheard-of things may be here further obferved. So admirably does God fhew himfelf before our eyes! and probably the relation would not be believed, if I defcribed and delineated that a Nymph iffues out of one fpecies of Caterpillars, which belongs to the fecond mode of the third order; and that out of this Nymph the Butterfly is afterwards produced; and that out of the fame fpecies comes a Worm alfo, which is again changed into a Nymph, according to the firft mode of the third order, and at laft affumes the form of a Fly. And further, that out of the fame fpecies of Caterpillars, arife two or three Worms, which are again changed into Nymphs of the fourth order, and thefe afterwards into fo many Flies. Laftly, that thirty, eighty, nay one hundred Worms have iffued thereout, which have been likewife firft changed into Nymphs, and afterwards into Flies. I have feen thefe twelve changes, which are very worthy of notice, diftinctly in only one fpecies of Caterpillars. And now, at length, I have learned that all thefe wonderful effects of Nature obtain likewife in water-infects; but this I have not yet fufficiently traced.

Though the changes of the inteftines, a little before enumerated, are very fingular in the Worm and Nymph of which I treat, thofe which the fpinal marrow undergoes deferves yet the greateft notice, and that preferably to the reft. For as this marrow in the Worm was twifted, as it were, into a curled lock; fo, on the other hand, we find it extended very ftraight in the Nymph, and almoft all its eleven knots, Tab. XLI. Fig. VII. 1, 2, 3, &c. dragged or feparated from each other. This is chiefly feen about the laft knots; but not about the foremoft knots, or thofe next to the brain, *a*; near or on the upper part of which I have delineated the cornea of the eyes. The firft knot, *b*, preferved its former fituation; but the four fubfequent knots, *c*, having fuffered a quite different change, were preffed clofer to each other than before, and expanded to a confiderable bump or fwelling; and therefore the nerves, fpringing from thence, were now conveyed in a very different manner. Nay, further, the origination of the fpinal marrow is alfo feen, ftretched and extended between the firft and fecond knot: and this, indeed, may be perceived ftill more plainly about the fixth, feventh, and eighth knot; and therefore only the three loweft knots, *d*, remain in their former fituation; though the laft of them is likewife more confpicuous than the two next above. If we would here follow Reafon as our guide, fhe would certainly have rather dictated, that the convolution of the marrow in the Nymph is extended in the

* This double conftruction of the ovary is almoft univerfal in flying infects, and it is the fame in almoft all the kinds of fifhes; and the vaft number of eggs bears likewife an analogy. In many fifh the body of the female is filled with this ovary, as entirely as in infects. The intent of Nature feems to be the providing, from the abundant eggs and young of fome kinds, food for the others; for it never could be the intent, that all the eggs contained in thefe ovaries fhould yield perfect infects.

Worm, ſince the Worm is two thirds longer than the Nymph: and hence it ſhould ſeem neceſſary, that the marrow in the Nymph muſt be thus twiſted, by reaſon of the contraction of the body, which, as it were, accommodates itſelf thereto ſpontaneouſly. But experience teaches, that all our reaſonings here are of no conſequence.

Wherefore, if any one well conſiders theſe changes and extenſions of the nerves, and the knots of the ſpinal marrow, he will clearly ſee, that the change of the Worm into a Nymph, and of the Nymph into a Fly, the inſect, in the mean time, being one and the ſame, is, in reality, very miraculous, and may be called, as it were, a new creation, or rather generation; the true cauſes of which we are at as great a loſs to inveſtigate, as the nature of God, who is the author of this work. This ſhould certainly excite us to acknowledge the offenſive cloud of our own blind ignorance in every thing, and afterwards to ceaſe from pride and arrogance. It teaches us alſo, how largely the miracles of God are expreſſed in theſe ſmall creatures: they are, as it were, ſpontaneouſly evident to any one, with the leaſt pains, in the inveſtigation. However, one may obſerve, that ſuch changes are likewiſe obſerved in the larger animals; for the ſpinal marrow of the embryo, which, in the beginning, is hardly larger than a pea, is alſo inſenſibly expanded as it grows larger: yet one cannot, on the other hand, deny that this is only a ſimple augmentation of the parts, which produces ſuch changes in the larger animals. But in the inſects there is obſerved a remarkable tranſpoſition of the parts, and an admirable accretion of the viſcera; which, as it is performed in a ſmall ſpace of time, deſerves to be called miraculous, nor can it by any means be diſtinctly explained: for our eyes never diſcover, nor can they ever diſcover, how theſe things are really executed. Add to this, that the adult animal here grows young as it were again, and muſt receive other additions, until it is at length cloathed in a more noble body: all which tend to the honour and glory of God, the Supreme Deity, the Author of all theſe miracles.

CHAP. VI.

Of the true manner in which the Nymph breaks out of its outer and inner coats; ſo that, by a kind of viſible reſurrection, the creature afterwards aſſumes the form of a Fly. Alſo of the pulmonary tubes and inteſtines, the coats of which are drawn off, and left in the exuviæ.

WHEN the time approaches, in which the hidden inſect, now changed into a Nymph, in its outmoſt uncaſt coat, is to attain the form of a Fly, which change it performs in the ſpace of eleven days, the ſuperfluous humours, wherewith its members are ſwollen, are firſt inſenſibly expelled by perſpiration. The little body of the Nymph alſo, as hath been obſerved before, is contracted unto the fifth ring of the ſkin: and hence the four laſt rings of the abdomen and tail become empty and hollow, or are all filled with air, through the aperture of the reſpiratory orifice in the tail. The Nymph likewiſe yet draws its breath through the ſame aperture.

If you deſire to ſee this, expoſe the Nymph a little to the rays of the ſun, and afterwards put its tail into water. Thus you will find, that it will breathe ſtronger than it did before, and, by expreſſing an air-bubble out of its body, and again ſucking it in, will manifeſtly perform the action of inſpiration and exſpiration.

The anterior part of the Nymph's body likewiſe draws back from the ſkin, and having partly deſerted the beak, head, and firſt ring of the breaſt, the little inſect afterwards lies at reſt within its ſkin; until its exhaling members have acquired due ſtrength and firmneſs to break open thoſe two membranes, wherewith it is now ſurrounded, and hindered from coming into light. All theſe things muſt be here remembered, that what I ſhall ſay hereafter may be properly underſtood.

If, however, the outer ſkin be opened about this time, very wonderful varieties of colours, ſuch as one can ſcarce imagine, preſent themſelves through the inner ſkin, with which the Nymph is covered. Some of the parts are changed from white into black; others are of a yellow, purple, brown, or very black colour, like pitch; others, from aqueous, have become membraneous; and, from this latter ſtate, again become hard: ſome become fleſhy; others again acquire an horny or bony hardneſs, ſo that, when preſſed, they crack and break aſunder.

It is likewiſe obſerved at this time, that the whole body becomes inſenſibly ſhaggy, and the feet and claws begin to move. All theſe things may be diſtinctly ſeen, provided one opens one of thoſe Nymphs conſtantly every day, until the time of change. But, for this purpoſe, it is neceſſary to lay them on white paper in an earthen diſh, or glaſs ſaucer, and then to make them ſomewhat moiſt with water, and keep them under a glaſs. In this caſe, the paper ſerves the Nymphs to fix their claws in, when they come forth under the form of a Fly; and I pour in a little water, to preſerve them from drying and ſuffocation.

When the creature is at length to come in fight, the outmoft fkin of the Worm begins to move about the third and fourth anterior ring, Tab. XLII. Fig. I. *a*. This motion arifes from hence, that the infect, now hidden within the fkin, ufes all its efforts to promote its exclufion, and to quit its inmoft coat as well as its exterior fkin together, at one and the fame time. This is conftantly the courfe of nature, in our fourth order of changes. It is obferved, on this occafion, that the fkin is divided into four parts: hence it happens, that the third *b* of the foremoft rings, and alfo the fifth, *c*, are partly feparated; and even thefe, as well as the fourth above, open very regularly and orderly in the breaft. After this, the infect immediately breaks open its inner coat, with which it is immediately invefted, and cafts it off, together with the fkin, breaking forth from thence under the beautiful form of a Fly, Fig. II. *a*.

But I would have it here obferved, that the breaking open of the outmoft fkin, as now explained, is not at all cafual or accidental; but is perfectly ordained by a conftant order, fince it always proceeds in the fame manner in all thefe changes. The fkin alfo is in thofe places, where it is broke open, fo circumftanced by the all-wife Author of Nature, that it eafily opens, as if joined together by futures.

When the Fly is thus produced, its wings are not immediately obvious, or diftinctly vifible; but are curled up, and wrinkled into folds, in the fame manner as I have exhibited in the Nymph. However, in the fpace of a quarter of an hour, which is well worth obferving, we fee that they are difplayed and extended, and become fmooth. The caufes of this fudden effect are the blood and air, which are then impelled forcibly into the veffels of the wings and pulmonary tubes: therefore, if the wings about this time be wounded, they fhed fome fmall drops of the creature's blood, like clear flowing water; and this never happens afterwards, when the wings are once expanded and dried, though you wound them never fo often.

When the wings are expanded, the little infect difcharges three or four fmall drops of muddy water, and immediately enters into another ftate of life: for the creature, that lived before in water and mud, now wanders thro' the air, carried by very fwift wings, and vifiting the graffy fields and meadows, enjoys a more noble and happy kind of life.

In the fame quarter of an hour, wherein this creature is produced, it hath alfo acquired the knowledge of every thing neceffary to do what it ought, and to avoid what may prejudice it; wherefore it never afterwards has occafion of a tutor, or director for any thing. Hence the birth of this infect by far excels the unfortunate condition of man, after he is born. He for fome years increafes or grows up, as it were, in difagreeable circumftances, before he has reafon, or a knowledge of thofe things which he ought to do, or avoid: but, on the contrary, this infect is of full maturity when born; nor does it increafe any more after the quarter of an hour, in which its birth is compleated; but it feeds itfelf with a moft diftinguifhed kind of pleafure, and lives on dew and fugared liquors, which it finds in the meadows and flowers: indeed, it fometimes nourifhes itfelf with blood, to the juft punifhment of the fins of Man, who is more miferable than the Worm fixed to the earth, and thrown into this world as into exile. This Fly naturally torments cows and cattle, that ferve for the ufe of man, in fuch a manner, that they run through the fields mad, as it were, with pain.

Relying with juft reafon on thefe things, I can at length affirm, that the aforefaid metamorphofis of the Worm into a Nymph, under which change the Nymph is for fome time, as it were, dead, and deftitute of motion, and, after the fhort fpace of eleven days, increafes into a Fly, by the wonderful alterations of the internal parts; may be juftly compared to the true refurrection from the dead, or, as it were, to a new generation. The human underftanding is, indeed, amazed at this; but at the fame time we are taught thereby, as with a vifible example, how near our refurrection and reformation is, when we love God above all things, and our neighbour as ourfelves; in which confifts, indeed, the real metamorphofis of the human mind. This, having then caft off the ancient dirt of avarice, pride, and envy, and changing thofe vile paffions for the moft fweet and gentle love of Chrift, lives afterwards eternally in a more perfect body.

The Fly, thus produced from the Nymph, exhibits two antennæ, or horns, Tab. XLII. Fig. II. *a*, on the head. The four anterior legs are jointed to the lower part of the thorax. The two laft are feen *bbbb* under the pofterior part of the body, and fhew very diftinctly their joints, and the two claws, with which their extremities are fortified. Two little apapertures are feen in the upper part of the thorax; but its pofterior region is girded round with a beautiful margin, near which, on each fide, are feen two little parts, with globular extremities, defigned for making a noife or found. The two wings are affixed *cc* to the fhoulder-blades. The body, *d*, is divided by fome yellow fpots, with black horny or bony rings, which are beautifully adorned above and about the fides with fine hairs. I had once intended to delineate thefe things magnified; but I am now fo ftinted in time, that I cannot execute this defign.

The other miracles of God, fhewn in this infect, muft be now exhibited to view; I mean, thofe which occur in the fkin, and in the inner integuments, which have been forfaken by this Fly. I fhall now fhew thefe exuviæ, or caft parts, diffected and magnified by a microfcope. In the hinder part of the outer fkin, the caft off pulmonary tubes, *aa*, which, upon the Worm's being changed into a Nymph, and contracting its body into the fourth annular incifion, had feparated from its interior parts, ftill adhere to the fecond, third, and fourth rings:

rings: and as the body was wrinkled at that time, it happened that theſe pulmonary tubes were turned out of it, through the poſterior apertures of the tail, and remained fixed to the reſpiratory points or breathing-holes of the outer ſkin. From conſidering therefore this poſition of the exuviæ, it is eaſy to underſtand how the inſect has at that time, beſides other changes, ſuffered ſo great a contraction of its body. The extended extremities, or ends of theſe pulmonary pipes, being protended forwards, are curled and twiſted, *b b*; which proceeds from hence, that when the Worm contracts its body upwards, from the tail to the thorax, theſe pulmonary tubes are, by their own inſertions, and this force, thrown out of the body: and hence it happens, that theſe being afterwards left to themſelves, they fly back, as it were, and from ſtraight run into curled ſtrings or cords. This I once plainly ſaw, when I opened the ſkin about that time.

The like operation has place alſo, with reſpect to the inner *c* coat of the inteſtines; which then likewiſe ſeparates from the body, and remains fixed to the ſkin, very beautifully repreſenting the complicated web of a Spider. Within, in this little inteſtine, which is of a beautiful white colour, are found ſome particles, like grains of ſand, clear as alum, and conſiſting of many points and diviſions. I firſt thought theſe were ſand; but I afterwards ſaw that when they were mixed with ſpirit of vitriol, they fermented very ſtrongly, which is not a property of ſand. And, therefore, as I am unable to explain the nature of many other parts, ſo I do not know what this ſubſtance is; whether it be of any uſe in the body, or whether it probably contains the calcarious, chalky, and alcaline particles of excrements? I therefore, here again, candidly confeſs my own great ignorance. If we invert this part of the inteſtines, and the tail, we may likewiſe ſee how the ſeparating inteſtine, Tab. XLII. Fig. IV. *a*, inwardly detaches itſelf from the inner cavity of the ſtraight gut or rectum, *b*; and, when ſeparated, remains fixed to the external orifice of the fundament, which opens *c* within the outer ſkin. This I have roughly delineated, the better to explain it.

In the anterior or fore-part of the Worm's exuviæ, are ſeen the legs, beak, eyes, Fig. III. *d*, and ſkull, *e*, left and caſt off together *. There is likewiſe ſeen the coat, which parted *f* from the internal ſurface of the gullet and ſtomach. But it is neceſſary to take notice here, that every thing, hitherto mentioned, happens when the creature firſt aſſumes the form of a Nymph.

When it afterwards, upon breaking forth under the form of a Fly, quits this outmoſt ſkin and the inward pellicle together, there are again other remarkable things obſerved, which I ſhall now deſcribe. In the firſt place, I exhibit, as now caſt off, *gg*, the hitherto hidden inward coat, which had inveſted all the Nymph's limbs and parts, and which is now irregularly broke open in the fore-part, together with its outmoſt ſkin. This may, indeed, be eaſily done, on account of its thinneſs. In its hinder part, one may ſee where the tail, *h*, or the extremity of the Fly's body, was before ſituated within it. In each ſide of this ſkin are ſeen the pulmonary tubes, rolled out, and all terminating *i i* in a pointed extremity, like ſo many ſmall tops or points of needles, tho' each of them may be very eaſily ſeparated into many branches.

But it muſt be here again obſerved, that theſe pulmonary tubes do not ſeparate or go off, when the Worm is changed into a Nymph: for, otherwiſe, the Worm muſt have crept out of its external ſkin; as, indeed, is always the caſe in ſome other orders of tranſmutations. But ſince that does not hold here, therefore the moſt wiſe Creator has ordained that theſe changes ſhall happen, when the Worm, on forſaking both its ſkins together at the ſame time, and being cloathed in more noble ornaments, and under this form afterwards dignified with the name of a Fly, is to come to light. Theſe things, indeed, afford us matter very worthy of conſideration. We are excited to induſtry not only by the ſmall Ant, but may draw knowledge and learning from the contemptible Fly. And thus all things tend, at length, to the honour and love of the Supreme Architect, whoſe works are evidently the open books of Nature.

* It is univerſal among inſects, that the creature which has put off its exuviæ, or caſt its ſkin, immediately appears much larger than it was before. This is indeed true in fact, as well as in appearance. The body has by degrees grown under the ſkin, till it is too large for it; and this is the very reaſon of the throwing it off. As the increaſe has been gradual, and the parts are ſoft, the ſkin has preſſed them together, and they lie cloſe; but as ſoon as this ſkin is caſt off, they diſtend themſelves, ſo as to appear in their proper form.

CHAP.

CHAP. VII.

Treating very particularly of the Aſilus, or Gadfly, and its external and internal parts, as well male as female.

NOW that we have ſeen the order in which the Worm grows or increaſes into a Nymph, and how this latter is at length changed into a Fly, and conſequently appears under three different forms, though it always remains one and the ſame inſect; it is neceſſary, for my purpoſe, to exhibit particularly the parts of the Fly. This I ſhall now attempt to do, and I ſhall begin with the male; and afterwards deſcribe thoſe parts in the female, which cannot be ſeen in that ſex.

The male Gadfly, conſidered externally, ſhews itſelf divided into the head, the thorax or breaſt, and the abdomen or body. Theſe three parts are joined together, as it were, by a ſmall filament; and this makes a moſt beautiful figure in Waſps. This is the reaſon why theſe creatures are called inſects.

In the head the eyes, horns, and proboſcis or trunk, are very conſpicuous. The eyes are ſmooth, of a dark browniſh-green colour; and they ſeem ſpotted, upon a tranſparent gold-coloured ground. Their ſtructure is like that of the Bee's eyes; for each conſiſts of a collection of many leſſer eyes, between the hexagonal diviſions of which ſome hairs are ſcattered up and down. A ſmall, black, horny margin divides theſe eyes one from the other. The hinder part of this margin, which lies upwards towards the thorax, is likewiſe adorned with three larger eyes; the two hindmoſt of which are ſomewhat ſmaller, and the two fore ones as large again. In the neck, or where the beginning of the medullary ſubſtance is joined to the cerebellum in us, there are obſerved two yellow ſpots.

In the foremoſt region of the head, where the margin juſt mentioned reaches towards the mouth, two very beautiful horns, of an obſcure blackiſh colour, are placed in the middle. Theſe are divided each into eight joints, whereof the lower are longeſt, and are ſet with fine hairs. About the mouth are likewiſe ſeen a conſiderable number of hairs, of a glittering deep gold colour. The mouth has no opening, as in other inſects; for the proboſcis or trunk, like an hollow little tongue, is here placed in the mouth; and through it, as through an hollow tube, the Fly, when eating, conveys its food into the ſtomach.

By preſſing the thorax with the fingers, this proboſcis will come in ſight out of the mouth: in its fore part appear two oval bubbles, Tab. XLII. Fig. v. *a*; the middle parts of which are applied to each other lengthwiſe, and between theſe the food paſſes to the ſtomach. Their upper part is beautifully divided with various pulmonary tubes, which, like ſo many ſemi-circles, run from one ſide to the other. The proboſcis alſo has briſtly hairs *b b* on each ſide of it, which, ariſing out of the outer ſkin of the mouth or lips, hide the trunk itſelf, when drawn back by the Fly. The inferior or lower part of the proboſcis has two ſmall *c c* appendages; out of the ends of which, conſiſting of a black horny bone, likewiſe ariſe ſome hairs. They are jointed into a ſingular kind of black *d* horny triangular bone, which gives conſiderable ſtrength to the membranous parts of the tube, which ſupports the proboſcis. Beneath this is afterwards ſeen another horny bone, which is of a different figure, *e*. I have not yet been able to diſcover the aculeus or ſting in this Fly, though it ſhews itſelf very viſibly in the Horſefly, which carries it encloſed in a ſmall ſheath. Whether the great tenderneſs and fineneſs of the ſting prevented my finding it, or whether I miſſed diſcovering it, I cannot ſay. Neither can I explain in what manner this little inſect ſucks the blood, ſince I have never learned this from obſervation. I have ſaid, indeed, in my general hiſtory of inſects, that theſe little creatures had a ſting or point in their mouth; which, I believe, to this time is the general conſtruction, tho' I cannot at preſent demonſtrate it.

The ſhape of the thorax on the upper ſide, or in the back, is oblong, and it is moderately hard like a horny bone. It is in ſome of theſe Flies, covered very thick with fine hairs. Its upper part is bent a little inwardly at each ſide: and hence it happens, that two holes, as it were, are there formed; beſides, each ſide of it is ſet with thin hairs. In the loweſt region of the thorax are ſeen ſix legs; they are articulated to the thorax. Each of theſe legs conſiſts of five joints; the laſt of which is again ſubdivided into five ſingle joints, and is armed with two rediſh claws, having their extremities as black as pitch. All theſe joints have alſo briſtly hairs, and are conſtructed or formed of a horny or bony matter, ſomewhat hard like lobſter-ſhells: within this the muſcles, veſſels and nerves are placed. On the upper and hinder part of the thorax are two wings, of an even and generally ſmooth ſurface; though they have ſome few hairs diſperſed over them. A conſiderable number of pulmonary pipes is alſo diſtributed through theſe wings, and theſe divide them as ſo many ſmall nerves. The membranous parts of the wings are ſomewhat wrinkled, or plaited with ſmall folds, and they are of a colour approaching to a pale red. The wings are, by the help of their joints, connected with the back; where the muſcles, which move them, are inſerted therein. Four ſmall folds of the wings are likewiſe ſeen there; whereof the lower are beautifully ſurrounded with hairs; and where the contracted wing reſts, they are received by a kind of hole or pit, conſpicuous in each ſide of the thorax;

and this likewise has some setaceous hairs, but not placed so regularly. Near these appear two globules, each of which is supported by a bent or crooked small foot or peduncle, and these resemble the iron head of a hammer. All the little parts, just now enumerated, serve for modulating the air; for, as this is driven out of the thorax into these cavities, hence is produced that crashing noise in the sides of the body, made by the Fly when it displays its wings in flying. The malleoli, or little hammers, in particular, are very beautiful, and such are found almost in all Flies: but I never saw them in any species of Bees; that is, the Bees have four wings: and therefore they produce their sound or noise in a quite different manner. The same may be also observed in Locusts and Grasshoppers. Indeed every kind of insect has particular instruments to vibrate and modulate the air. The part of the back opposite to the abdomen, is adorned with a yellow margin; out of which arise two sharp-pointed little parts, like sharp needles, terminated by black points. However, you may more easily discover these little parts by the touch than by the sight, because they are surrounded with a great number of hairs.

The abdomen, in like manner, consists of a horny or bony substance, and being set all round with hairs, has five yellow spots on each side, which are here and there as if folded up, and laid smooth, and without hairs. It is moreover divided into several rings, which are disposed in the same manner in the male as in the female: though, in respect to the particular structure, there is some difference between them, as far as they constitute the Fly's tail; but this difference cannot be seen, unless when these parts are pressed backwards.

As to the external parts, there is no difference between the male and female, except with regard to the bigness of the body: the male is a full third part less than the female, which is likewise the case in the Worm also, and the Nymph; for those which are to produce males, are less than those which are to yield females. The female must carry in it an ovary, which, as it contains so great a number of eggs, that it cannot be comprehended in a narrower compass, it is therefore necessary that she should have a larger body. To make this the more evident, I shall now describe the inward parts of the Fly, and their difference in the male and female. Let it be here observed, that it is a female I have delineated here, and described in general.

Before I proceed to the internal parts, I must observe, that all the Flies which belong to this species, do not exactly agree with one another, in regard to their spots, colours and hairs, which is also the case in their Worms; between which there is great difference in regard to their paler or fuller colour.

Now, if, in order to settle the dissection of these Flies, you desire to kill them in such a manner as not to hurt any of the parts, there is nothing so proper for this purpose as spirit of wine, in which they die immediately: however, I could not entirely kill the Worm in this liquor. I have killed a young Fly in the space of three hours, by the smell of Brasil tobacco, put near it in a flask: and this indeed I have often done since.

In the head of a male Fly of this species, two days old, I observed that little particles of fat became considerably smaller than I before described them in the Nymph. When I had afterwards removed the cornea from the eyes, the colour of the uvea, which still lay within that, appeared of a bright red. I observe also, that the colour of the uvea is very different in proportion to the age of the Flies: for those that have very recently cast their skin, sometimes shew the uvea of a very beautiful and full orange colour.

All the muscles of the legs and wings, which are inserted in the horny or bony investing coats of these parts, were in this Fly entirely perfect. I found little fat here. But the belly, when opened, appeared to be very full of it. This fat was of a purple colour, and its particles globular; so that at first sight I took them for eggs. These fat particles very easily separate at this time from the pulmonary pipes. These tubes were become much less, and more contracted, on account of the great loss of the considerable coats which they had cast off; but I could not find any tube among them dilated into vesicles, as is the case in many other insects. I further observed also, that the largest branches of the pulmonary tubes, which I have before described in the Worm, were here in the Fly compressed, and insensibly worn away, as it were, or abolished: and the same thing is true with respect to the bags, out of which the Silkworms spun their silken threads.

I observed also two considerable pneumatic bladders of a pear-like shape; one of which I here delineate, Tab. XLVII. Fig. VI. *a*. They were large, and very much dilated, and were somewhat curled in the curvature of their tops, in the manner of those little purses, in which the earth Spiders carry their eggs about them: this happens probably, because these bladders have not been extended as much as they might. Each of these was terminated by a closer tube, *b*, composed of orbicular rings; out of the sides of this other small branches, *c c*, issued here and there; two of which I here exhibit magnified. These pulmonary tubes are principally conveyed towards the sides of the body, under the wings, and there forming small orifices, they afford the air by which the Fly makes or produces its noise.

The stomach and intestines were in this Fly very much contracted. I found a little air in the stomach, and in its hinder part near the pylorus, a brownish yellow fluid. The little intestine found in the other intestine, was wanting in this subject, having been wasted away. The four convolutions of the four closed or blind intestines, were here found forced out of the breast into the belly. The rectum shewed itself dilated to a considerable width, and filled with a white moist substance like chalk.

Below, in the abdomen, were seen the genital parts; the penis, the testicles, and the seminal bladders. The penis is situated underneath, within the last ring of the abdomen, thro' which it erects and ftretches itfelf. Its forepart is divided into three horny or bony points, Tab. XLVII. Fig. VII. *a*, variegated with a palifh yellow colour, fomewhat approaching to red: the middle one of thefe is properly the penis, which can erect itfelf internally, and pufh through the horny little bone, wherewith its hinder parts are invefted. It is connected as by two joints, *b b*, with black horny little bones, twifted into ferpentine windings, which I here reprefent, joined to the hinder part of its horny fheath. Moreover, this can bend itfelf in fome degree about the middle, *c*; its cafe, or fheath, being there a little more membraneus: hence the penis feems to exhibit a joint in that part. The laft or extreme ring of the belly, wherewith the penis is articulated, is likewife adorned with two margins or verges, which are fmall, horny, or bony, black, and confiderably ftrong, *d d*; and in the forepart, are, as it were, jointed with the horny little bones, which are bent in a ferpentine manner *e e*. I have here delineated that ring open: for all thefe horny little bones are clofely joined together, and cover, as it were, the penis.

The foft and nervous part of the penis, twifted in a ferpentine *f* manner, runs inwardly into the cavity of the abdomen, and is there at length dilated into a confiderable knot, *g*; into which the tefticles, *h h*, and feminal veficles, *i i*, difcharge their fperm through four orifices, and thus convey it to the penis. The tefticles, when diffected, fhew themfelves to be compofed of very numerous, fmall, very fhort and tender *k k* tubes, with their ends clofed; all which threw their fperm into the vas diferens, *l*, by which it is conveyed on further. The feminal veficles are not fo confiderable; but they deferve notice, on account of fome bendings and curlings, *m m*; they terminate in delated extremities. Their fperm, as well as that of the tefticles, is white; though the tefticles are not fo white as the feminal veficles.

The fpinal marrow is here difpofed in the fame manner as it is in the Nymph.

I find the fame parts in the female as in the male; only that an ovary is found in that fex, inftead of the male genital organs. This ovary is divided into two parts, Tab. XLII. Fig. VIII. *a a*, and being *b* faftened to the laft rings of the abdomen, it opens there by a large orifice, and difcharges its eggs; thefe the Fly always drops into the water: this is likewife the practice of the Perla or Dragon-fly. Thefe hinder rings of the body, are here and there very beautifully variegated with black, horny, or bony fpots of different figures, *c c c*, and are likewife beautifully adorned all round with hairs *d*.

The eggs in the ovary feem to be exactly fpherical, and to exhibit each an opening in the middle of it, *e e e*: but this is only a falfe appearance, produced from their too obfcure colour. In reality thefe eggs, are oblong; and they become the longer and more acute, *f*, as alfo larger and more confpicuous, the longer time has paffed fince the Fly's change; fo that they infenfibly fill the body more and more. But if thefe eggs be laid before a microfcope, that magnifies in a great degree; then their real figure is difcovered, together with the pulmonary tubes, *g*, which connect them every where, and which furnifhing many fhoots, *h*, diffufe *i i* themfelves through the whole ovary in feveral beautiful branches. No veins or arteries are feen here; becaufe thefe little creatures have white blood, as alfo on account of their great fmallnefs.

In the young Fly thefe eggs are very tender, and of a beautiful colour; which becomes the ftronger or fuller, in proportion to its age. In one ovary of this kind, I have diftinctly counted about four hundred and forty eggs: hence it is evident, what a great number of Worms one Fly may produce.

I have placed water, fweetened with fugar, before fome of thefe Worms; but they did not touch it, and died the fourth day. Others lived much longer, and the more fo, the more they were expofed to the cold and rain; for then almoft all infects abftain from eating. I have neglected to offer them blood.

In one of thefe Flies, which I opened alive, all the fat was confumed, fo that no part of it remained, but thofe purple little membranes, with which I had obferved it before furrounded.

Laftly, near the orifice of the ovary, which difcharges, Tab. XLII. Fig. VIII. *k*, itfelf, thro' two ducts, I have difcovered thofe three very beautiful little knots, whereof I have before made mention in the Nymph. The extremities of thofe Nymphs are twifted, *l*, or turned like a fnail-fhell: and they are then inflected or bent, *m*, in a fingular manner, then curled, *n*, and run towards the laft ring of the belly, and are placed *o* near the ovary. Where thefe knots form *m* their bending, fomething like a common membrane joins them together. But if they be diffected, there are as many pulmonary tubes feen enclofed therein, as they are in number. The coat or membrane, which invefts thefe pulmonary tubes, entirely dries away and perifhes, if thefe are put on a glafs, and leaves the tubes bare with open cavities. By opening the faid knots alfo, one may turn the air-tubes out of them unhurt.

The ufe of thefe little parts is utterly unknown to me; I cannot even conjecture for what purpofe they are formed. There are alfo many other parts of this infect, concerning which I am as much at a lofs. Wherefore, all who read thefe matters, as well as myfelf, being convinced of our ignorance therein, are obliged fubmit to before God; who hath fhewn himfelf fo incomprehenfible and adorable in this infect. We are obliged to extol him with praifes, for that he hath been gracioufly pleafed to difcover to us fo many, and fuch great things in this creature. If we cultivate and exercife together thefe two duties under fuch refearches, the vifible things will ferve to excite and encourage us to know and fee God, from thofe objects which he created, and to love him cordially, and like children, as the fupreme venerable Deity.

The End of the Hiftory of the Gadfly.

*A Letter written by the author to Mr. Thevenot, on the nature and anatomy of the Worm bred in rotten cheefe, or the Acarus, and called by us the Mite, and of the Fly produced from it.**

SIR,

I Doubt not, but at the time when you held weekly conferences at your houfe in Paris, and thereby made it a general place of meeting for the learned, fome of your inquiries turned on the nature of Mites, their fingular difpofition, and furprifing manner of their fpringing up into the air. I therefore take the liberty of fubmitting this little treatife to your judgment, which I refpect and value infinitely more, than the opinions of many of the profeffed litterati of the prefent age, whofe inquiries into natural things, feldom go deeper than the furface.

I am not ignorant, that the illuftrious Redi has wrote with great knowledge and accuracy concerning Worms, which are bred in cheefe; but I know alfo, that he could not poffibly be thoroughly acquainted with all the circumftances remarkable in thofe infects; and that the great number of uncommon experiments which he propofes, could not but hinder him from applying himfelf thoroughly to all parts of the fubject, efpecially as he, at the fame time, paid his attendance at the court of the great duke of Tufcany.

I have therefore taken upon me to lay before you, moft illuftrious philofopher, a full account of this little Worm, and its Fly, their external appearance, their difpofitions, and their internal ftructure; for I can take upon me to affirm, that the limbs, and other parts of this Worm are fo uncommon and elegant, and contrived with fo much art and defign, that it is impoffible not to acknowledge them the work of infinite power and wifdom, to which nothing is hid, nothing impoffible. You will fee thefe minute creatures have, as well as the greateft, a brain, nerves, mufcles, lungs, falival ducts, a ftomach, fmall and large inteftines, cæca, or blind guts, pinguiferous or fat membranes, and the feveral other vifcera.

The external parts of the Mite.

ALthough this Worm is very common, I have thought it not amifs to give a figure of it at its full growth, and of its natural fize, Tab. XLIII. Fig. I. as names are equivocal, and there are many who know but little of it. Thefe fmall creatures being generally held in deteftation, though fome eat them voluptuoufly with the reft of the cheefe, from a vulgar notion, that they are formed out of the beft parts of it; whereas in reality, they proceed folely from the eggs of a common Fly, as I fhall prefently demonftrate. But before I undertake to explain the difpofition of this Worm, and give fome account of its internal parts, as they appear on diffection; I fhall defcribe its external parts, as well as fuch internal ones, as the tranfparency of the outer ones affords us an opportunity of examining, without being obliged to diffect, it.

The Mite, when viewed with the microfcope, appears divided into twelve fections or rings, Fig. II. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. The firft of thefe rings, properly fpeaking, forms the head *a*, the fkin of which, as likewife that of every other part, is tough and firm like a piece of parchment; fo that it is no eafy matter to break or wound it, though the Worm leaps with a furprifing violence, on being ever fo gently touched. The forepart of the head is, in a manner, divided or feparated into two tubercules, from which arife two very fhort antennæ, or horns. Between thefe two divifions of the head, there conftantly appears, through the tranfparent fkin that covers it, a fmall particle, which, like the head, confifts alfo of two divifions. This little particle really contains the organs conftituting the mouth, which are of a fubftance between bone and horn, and produce on their forepart two little black claws, which ferve the Worm not only as fuch, but likewife for feet, and in the place of teeth. We may alfo clearly perceive thro' the infect's tranfparent skin, that it can move thefe claws in and out, together with the already-mentioned parts of the mouth, in the fame manner as the Snail thrufts out, or draws in, its head and horns.

The next ring is very remarkable on this account, that the pulmonary tubes of the infect fcarcely open any where elfe, except in the hindermoft ring of the body, where there are two more: I could never difcover any other breathing-holes, or apertures, in this infect. Thofe in the front ring next to the head, are very large. Thefe extremities, or rather the beginnings of the lungs, Tab. XLIII. Fig. II. *b.* are curioufly contrived, and elegantly conftructed. On the forepart, where they are thruft out beyond the fkin, they are of a membranaceous fubftance, fomewhat white, and very delicate; a little lower they fwell, as it were, into a fmall belly, and grow yellowifh, and in fome mea-

* It has been a cuftom to call any fmall creature found in cheefe, in Latin, Acarus, and in Englifh, Mite. This author takes the the accuftomed liberty of fpeech, and gives, in the prefent account, the name Mite to the Maggot of a fmall Fly; but the creature we commonly call Mite in England, and which is moft univerfally called Acarus in Latin, is of a different kind; it is made fmaller than this Maggot, and appears like a moving particle of duft. This is the Acaris of the antients, which Ariftotle obferved in decayed Bees-wax, and was called the leaft object of the human fight. This Mite has fix legs, an oval or rounded body, with a hard fkin, and very diftinguifhable eyes. The Maggot here treated of under the fame name, is a creature altogether diftinct.

fure

fure to appear of a golden brightnefs. After this, they grow narrower towards the third ring, where we may plainly perceive, through the infect's clear skin, that after acquiring a filver whitenefs, like mother of pearl, they unite with the branches of the trachea, ferving as larynxes. One great advantage the infect draws from thefe openings, being placed forewards, near the beginning of the third ring, is, that when it draws in its head and legs, as it burrows in the moift cheefe, thefe larynxes are covered by the folding of the skin. A contrivance worthy of its great Author, the fole fountain of every thing good and wonderful. Within the third ring there plainly appears, through the tranfparent skin, the two great branches of the wind-pipe, which communicate about the beginning of the fourth ring, by a very confpicuous anaftomofis or inofculation. There are alfo many other fmaller branches of the trachea iffuing from the two great branches, which are placed within the third ring; and thefe fmall branches afcend towards the fecond ring, and toward the head. I have omitted thefe ramifications in the drawing, for fear of rendering it confufed. There appear befides, tho' fomewhat obfcurely, fome other internal parts, through thefe rings. In the fourth ring there are feen two more branches of the trachea, iffuing on each fide of the breaft from the two main trunks *cc*. Of the two fmall branches laft mentioned, one goes to the fourth, and the other to the fifth ring, where they join the branches fpringing from the trachea in this place by a double inofculation, or anaftomofis, that is eafily difcernible.

I do not find, that the greater branches of the wind-pipe form a mutual inofculation, or anaftomofis with each other, any where, except about the beginning of the fourth ring; but the fmaller branches arifing from the fides of the greater, and which appear very diftinctly on each fide of the body extended all over the annular divifions, communicate with each other in a very obvious and confpicuous manner. This may be beft feen on the declivity of the breaft and belly, above the borders vifible in thofe places, as alfo in the rings of the left fide, marked in the figure with the numbers 5, 6, 7, 8, 9, 10, 11, 12, and the letters, Tab. XLIII. Fig. 11. *ddd*, &c. There appear, befides many other, fmaller branches in the fame places, which fpring from the greater, and extend to the vifcera within.

All the other rings, from the fifth to the eleventh, are conftructed alike; and the ramifications of the pulmonary tubes, which fhew themfelves thro' thefe rings, are nearly of the fame form: the principal difference, and that too is only accidental, as it is called, is, that the other internal parts of the Worm fhew themfelves a great deal more plainly thro' fome of the rings, than they do thro' others. In the fifth ring fome particles of fat may be difcerned thro' the skin *e*, and fome more, tho' very faintly, in the fixth. In the feventh and eighth, I could perceive fome of the cæca, or blind guts, or clofed inteftines *ff*. Thefe, on account of their contents, appear of a very pale colour, in fome degree approaching to green; the fame alfo I could fometimes perceive, pretty diftinctly, thro' the ninth ring, tho' at other times very little or not at all. In the tenth ring, and between the principal trunks or branches of the wind-pipe, which extend themfelves along the back of the Worm from one end of its body to another, there generally appears a confiderable branch of the trachea *g*, running to the internal parts. In the eleventh ring, there is feen a very remarkable particle of fat *h*, refting upon two branches of the wind-pipe; but it has been only in fome Worms that I could perceive this: it is not univerfal.

The twelfth ring differs in conftruction from all the others; for the two greater branches of the trachea terminate there, projecting at their extremities in the fame manner as the leffer branches of the trachea do beyond the furface of the body. The projecting parts are, like the other breathing holes near the head: they are of a pale colour, but formed in a different manner, as may be feen by looking over the figure.

To conclude: the furface of this twelfth ring, is covered with a variety of prominent tubercles, and little cavities like wrinkles; the ufe of which I fhall hereafter defcribe.

Of the difpofition of the Mite.

THUS, Sir, I have defcribed, in a few words, the external parts of this Worm, and fuch of the internal ones as appear thro' its tranfparent skin. But all thefe particulars will appear of little confequence, when compared with the wonderful contrivance that is feen in every part, when more minutely examined: fuch a contrivance, as the great Architect of nature alone can thoroughly underftand, or could form; the moft ingenious inventions of man being, in comparifon with it, lame and defective.

The figure I here give of this Worm, which is furprifingly ftrong, and has a moft vigorous conftitution, reprefents it lying on its back, and feizing its tail with its teeth or claws; but this pofture is not, as you may guefs, the natural condition of this Worm, nor is it ever found lying on its back, when alive; fo that my only defign in giving it thus, is to be better able to explain the manner of its leaping, in the moft fatisfactory terms. By turning the figure, you will have a moft exact and natural reprefentation of the little infect, preparing to make a fpring.

When this creature intends to take a leap, it firft erects itfelf upon its anus; in doing which, it is greatly affifted by the prominent tubercles

tubercles of the twelfth ring, which enable it to maintain an equilibrium, by projecting more or leſs at its pleaſure, from the body. Immediately after this, the creature bends itſelf into a circle, and having brought its head, Tab. XLIII. Fig. III. towards its tail, it preſently ſtretches out its two black crooked claws, and directs them to the cavities formed between the two laſt or hindmoſt tubercles of the body, where it fixes them in the ſkin; as the ſecond figure, done from nature by the help of a microſcope, accurately repreſents.

The Mite having thus made itſelf ready, contracts its body with ſuch force, that from a circular, it becomes of an oblong form, Fig. IV. the contraction extending in a manner to every part of the body. This done, it again reduces itſelf with ſo prodigious a force to a ſtraight line, that its claws, which are ſeated in the mouth, make a very perceiveable noiſe on parting from the ſkin of the laſt ring of the body: and thus the Mite, by firſt violently bending, and afterwards ſtretching out its body, leaps to a moſt extraordinary height, if compared with the ſmallneſs of the creature, in conſequence of the ſtroke the body gives in recovering its place on the cheeſe, or wood, or any other ſubſtance upon which it was before lodged.

I have indeed ſeen a Mite, whoſe length did not exceed the fourth part of an inch, leap out of a box ſix inches deep, that is, to a height twenty-four times greater than the length of its own body *; others leap a great deal higher. But this Worm does not always erect itſelf perpendicularly to take a leap; it very often prepares for this when lying on its ſide, though the firſt is the commoneſt method; but whether it erects itſelf, or lies on its ſide when about to leap, it never fails to bend its body into a circle, and afterwards to reduce it to a ſtraight line.

If, Sir, you ſhould be deſirous of examining with your own eyes, theſe ſurpriſing miracles of God's power and wiſdom in this abject creature, you need only place the Mite in a drop of water, upon any white ſurface, and adapt it to the microſcope in this ſituation; for, though it cannot leap in the water, you may diſtinctly perceive it endeavouring to do ſo, by ſeizing its anus with its claws, and making every other poſture, exhibited in the ſecond, third, and fourth figures.

This may alſo be ſeen in another manner, by faſtening the Mite with a little paſte, made of ſtiff ſtarch, on the point of a very ſmall needle made for the microſcope, as it cannot looſen itſelf, ſo as to perform its leap in this ſituation. Another method is, to roll the Mite about a little upon a table, and handle it till it has loſt a great deal of its ſtrength; for, in this condition, it takes hold of its anus very irregularly, and ſometimes fixes its feet into the pulmonary tubes placed about that part; you may then very conveniently ſee in what manner it extends its claws upon this occaſion. Our common friend, Dr. Matthew Slade, will confirm all theſe particulars, he having had the pleaſure of admiring, together with me, all theſe prodigies of nature.

An anatomical deſcription of the internal parts.

TO kill ſome of theſe Worms for diſſection, I threw them into rain water, where they died, but not till after ſix or ſeven days: they are fitteſt, however, for anatomical diſſections, at the end of two or three days, lying in water; for though ſtill alive, they are benumbed. On being taken out of the water, at the end even of five days, they will crawl, however, and ſometimes leap about as briſkly, in a manner, as ever, and ſometimes live after this to become Nymphs, and afterwards Flies.

I could diſcover no eyes in the Mite's head; but the firſt things that preſented themſelves in that part, on diſſection, were the claws, which I before mentioned by the names of teeth and legs, as indeed I have found by experiment, that they will anſwer the ſeveral purpoſes of all thoſe parts. The inſect makes uſe of them as teeth, in ſcraping off the cheeſe, and afterwards ſwallowing it, ſo that it is but reaſonable to call them by that name: next the Mite employs them to walk with, ſo that one would imagine it walked upon its noſe. This may be ſeen, by placing it upon a piece of fine linen, or paper; for it fixes theſe two parts into the pores of the linen, or paper, and then draws after them the reſt of its body. Thus they deſerve the name of feet: but this is not the only manner in which this creature crawls; it can likewiſe move itſelf by an undulation, or waving motion, of its body. Finally, theſe parts, may be juſtly conſidered as claws, not only upon account of their reſemblance to thoſe parts in other animals, but alſo, becauſe it is with them that the Worm takes hold of the laſt ring of its body, ſo as to bring its mouth and anus to meet together.

Theſe teeth or claws are very ſharp on their fore part, and they are moderately crooked, almoſt like thoſe of hawks and eagles, Tab. XLIII. Fig. V. *a a*. Nearer the root they grow broader, and they have two apophyſes or ſwellings, wherein the muſcles, that ſerve to move them, are inſerted. Theſe teeth are articulated with the mouth and palate, which are two little black, oblong, hollow, horny bones, with which the pharynx is alſo connected. Theſe little bones, from a ſlender beginning, *b b*, afterwards become broad, and at laſt terminate in four appendages, *c c*, which are in a manner of a membranaceous ſubſtance: but in the fore part,

* We may admire in this inſtance the powers nature has given to different creatures, and their limitations, to anſwer neceſſary purpoſes, and not for miſchief to mankind. If nature had given this power to the ſerpent kind, how terrible would it have been! A Viper would have thrown itſelf from a concealed place, ſeventy-two foot at the traveller; a Rattleſnake an hundred and fifty: this being the proportion to the length of their bodies.

part, they are connected in the middle, with two other horny, and very ſingular bones, *d*, which ſerve to keep them in their places, and at a proper diſtance from each other.

The gullet, which lies between theſe appendages of thoſe little bones I have been deſcribing, and in their hollow part, becomes conſiderably wider in the Worm's thorax, *e*, where it, in a manner, forms an ingluvies or large hollow.

Under this are ſeen four appendages, cloſed at their ends, *f f*, which are, as it were, cluſtered about and ſurrounded by little globular particles of a fatty matter, but of a peculiar nature. They are indeed properly made up of theſe. As yet I cannot determine what theſe particles ſhould be called, or the uſe of them may be, unleſs, perhaps, they may ſerve to moiſten the food of the Worm, in its paſſage through the œſophagus or gullet, and thereby render it of eaſy digeſtion.

The ſtomach, *g g g*, offers itſelf next to our conſideration. It is very long, as is the caſe in all other inſects, while they continue in the Worm or Caterpillar ſtate. It is ſupplied with a great number of ramifications from the windpipe; but I have omitted them all in the figure, except two principal, and ſome other ſmaller, ramifications diſtributed over the ſurface, *h h h*. The length of this ſtomach is ſo very conſiderable, that one might eaſily miſtake it for a gut, and deſcribe it as ſuch; and no doubt, I ſhould have been myſelf of that opinion, had I not had an opportunity of comparing together the conſtruction of this, and of the ſtomachs of other inſects. This ſtomach is of a membranaceous ſubſtance, in which there appear ſome muſcular fibres through its tranſparent coats. All the contents of the ſtomach were white: I have endeavoured to repreſent them in the figure by ſome dots, as ſeen through the coats of the ſtomach, *i*. The ſtomach appeared alſo inveſted with numerous particles of fat; but I did not diſcover this laſt circumſtance in the ſtomach, till after I had dried it on a thin piece of glaſs.

Lower down, towards the end of this channel, there riſe from it two little ſlender inteſtines, *k k*, like thoſe found in all other Worms or Caterpillars, that I have yet diſſected, and even in the Louſe. I call theſe cæca, or blind inteſtines. In the Mite, theſe two inteſtines divided, each into two others; two of theſe contained a greeniſh yellow ſubſtance, *l l*; and the two others, a matter that was partly green, and partly white, and looked as if it was coagulated, *m m*; but what was very ſurpriſing, the motion of this ſubſtance through the inteſtines was ſo quick, that my eyes could not keep up with it; and, on my cutting one of the inteſtines in two, it flowed from it with great rapidity. This I obſerved in a live Worm, that I diſſected; but in another, which began to putrify, I found the coat of this inteſtine diſſolved into an infinite number of little fatty lumps. In both, theſe inteſtines were of a prodigious ſmallneſs; but from the motions of the matter contained in them, we may reaſonably conclude they are furniſhed with muſcular fibres, though I could by no means obtain a ſight of them, as they evade by their extreme delicacy, the ſharpneſs of both our eyes and inſtruments, which are at beſt only fit to examine viſible and ſenſible objects, and even theſe very imperfectly. How much therefore are we bound to humiliate our hearts, when, on account of our great weakneſs, we cannot thoroughly ſearch into any one of God's creatures! Theſe inteſtines had alſo their pulmonary tubes, *n*. And who can tell how many more wonders may yet remain hid in them!

The pylorus, *o*, or opening of the ſtomach, appears below the inſertion of the four inteſtines I have been juſt deſcribing, and near to this is the gut colon, *p p*, which is followed by the rectum, *q*. I could diſcern the very extremity of the rectum, *r*: it was of a ſomewhat different form from that which I have given it in the figure; for I there repreſented it as it appeared on my ſqueezing it at the fundament out of the Mite's body.

It is extremely remarkable alſo, that two of the cæca or blind guts, were ſo united with particles of fat, *s s*, that their cloſed extremities appeared firmly fixed in them, and connected with them by means of a great number of pulmonary tubes. In the figure I have only repreſented this circumſtance in one of the inteſtines. There are in this creature a great number of theſe particles of fat. They are of an oblong oval form, ſometimes double, and ſometimes hung about with appendages, round, hollowiſh, and flat, as may be ſeen in the two little portions of this fat, which I have here repreſented, *s s*.

On examining this fat with a powerful magnifier, every diviſion or lobe of it appears wrapped up in its own particular membrane. We may, even by this means perceive, that every ſingle particle of this kind, contains an infinite number of globules of fat, Fig. VI. *a a a*, which flow out of the lobe as ſoon as it is opened, and mix confuſedly together; ſo that, a variety of branches, compoſing, as it were, a little tree, are formed by the combinations of the concurrent lobes. The particles of this fat are of a duſky white, and, by this means, they exhibit in the Worm a ſpectacle, whoſe beauty no words can properly deſcribe; but we need not think this extraordinary, as it is effected by the Omnipotent Being, who, with a word, produced all things.

It is very entertaining alſo, to conſider in what manner the pulmonary tubes, which are of a bright ſilver whiteneſs, Fig. VI. *b*, run every where, and in every poſſible direction, through theſe pinguiferous or fat veſſels, ſo as to diſtribute themſelves principally over the particles of the fat, where this ſubſtance is laid up in little round lumps; at the ſame time, that in the interſtices of theſe lumps, they run into one another without any apparent order.

On one ſide of the gullet, there lay a very delicate and ſmall tube, ſtretching to the jaws, and the horny bones conſtituting the palate and mouth; but I have not as yet been able to trace this tube perfectly to its origin. I found that it divided itſelf, in the breaſt, into two ſmall channels, each of which widened again into an oblong globular bladder, Fig. V. *t t*, and then became

came again contracted into a narrow tube, which reaffumed once again the form of a bladder, beautifully adorned with a great number of pulmonary tubes running over the whole furface, *u u*. Some particles of fat very regularly placed, and moft curioufly contrived, furrounded one fide of thefe glandular veffels, *x x*, and underneath, extended into a kind of blind or clofed appendages, *y y*, fuch as I had never obferved before in the fat of any creature.

Nor can I tell the ufe of the particles laft defcribed, though I have reafon to think they perform the office of falival glands and ducts. For, as the Mite fpins no web, and thefe baggs are clofed behind, I do not think any other fervice can be fo properly attributed to them.

The pulmonary tubes, which are diftributed through all the parts we have been furveying, are conftructed in the Mite after the fame manner as they are in other infects. That great anatomift Malpighi, has given an inftance of this in his account of Silkworms; and I have, myfelf, frequently done the like in this work. But the rings compofing thefe tubes, are not fo very numerous; for which reafon, they are of a more membranaceous and flexible ftructure.

The motion of thefe pulmonary tubes is feen very evidently through the fkin, on examining with a microfcope the Mite, held on the point of a pin run through its head; for, as the infect in this condition turns and twifts itfelf a great many ways, the pulmonary tubes affume, in confequence of its motions, a variety of appearances. Sometimes they are ftretched out to their length, at other times they are bent in a ferpentine manner, or coiled up in form of a circle; but notwithftanding fo many diftortions, the rings compofing them always retain their form, and never collapfe. Thus has the Omnipotent Architect given us the fpecimen of a tube, fo perfectly flexible, that the moft violent contortions cannot do it the leaft injury.

The brain is fituated in the neck, near the horny bones, that form the mouth and palate of the infect. This fituation of the brain makes it fall lower in the neck, on the Worm's pulling its feet into its mouth; and, on the contrary, it is drawn forward, as often as that creature thrufts out its fnout: this is very much the cafe alfo in Snails. What atheift is there, who would not be confounded and ftruck dumb, on examining attentively the wonderful contrivance in the vifcera of animals? For my part, I dare challenge mankind to defcribe properly the fmalleft portion of the meaneft creature that crawls upon the earth. Whoever fhould undertake fo bold a tafk, would lofe his eyes in the attempt. For, there is no doubt but any one, who, in this vale of tears and ignorance, fhould fully and immediately behold the divine fun of thefe truths, which God has treafured up in his creatures, would forfeit fight for his prefumption. Such has been the unhappy, though deferved fate of all thofe, who have attempted to difprove and overturn by human reafonings, and fenfible experiments, the divinity of the Creator, fo clearly fhining forth in the whole nature of things. Whatever is a fenfible object, muft lie within the fphere of the fenfes; but our fenfes are coarfe, and cannot of themfelves teach us any truth, unlefs prior ideas of it have been impreffed upon us by him, from whom we derive our exiftence. This, father Malabranche has moft inconteftably proved in his inquiry after truth.

The brain in the Mite confifts of two globular parts, which in a manner conftitutes its right and left portions, Tab. XLIII. Fig. VII. *a a*. Near the brain is fituated the beginning of the fpinal marrow, which in this place is always opened, fo as to give a paffage to the gullet. From the fore region of the brain there iffue fome confiderable nerves, which dilate a little, at the diftance of half their length from their origin, *b b*. But this particular is not obfervable in every Mite. Thefe nerves at length fwell into two diftinct and very confpicuous nodules, *c*, from which arife two fmaller and very delicate nerves, *d d*. I could not trace thefe far enough to know what parts they run to: I believe it is to the mufcular parts of the mouth, palate, and feet. Next under the brain, and from the beginning of the fpinal marrow, there arife two pair of very flender nerves, *e e*, which adminifter to the vifcera in the abdomen, and to the mufcles moving the rings of the body. Under thefe appear two confiderable nerves, which, after dilating into two oblong globes, *ff*, clofe again, and then form two other globes, fmaller than the former; from which there arife again two nerves: but what thefe nerves are, or what purpofes they ferve in this infect, I cannot tell. I believe, indeed, they exift ufelefsly in the Worm, and are to work the mufcles of the wings, when it becomes a Fly. From each fide of the fpinal marrow there iffue a great many other delicate and fmall nerves, *g g*, which are all diftributed to the inner parts of the creature, and to the mufcles of its body; and many of thefe nerves fubdivide into various ramifications, *h h h*.

The fpinal marrow will appear very fhort, if we compare its length with that of the entire infect; and the fame may be faid of the body of the Fly into which the Mite turns. It is therefore neceffary, that the nerves, which are extended to fo great a length, fhould contract themfelves, and become fhorter, at the time that the Worm begins to change to a Nymph. In animals, whofe blood is of a red colour, fuch as Dogs and Calves, I have often obferved, that the nerves fhrink up, as Serpents do, into rings, or like a fpiral, as often as the part to which they are fixed undergoes any contraction: and this is chiefly obfervable in the nerves of the mefentery; whereas in the Worm now before us, the nerves are in every part equally contracted. This likewife happens in the Coffus, or Worm of the Beetle, where this contraction affords a very uncommon and very entertaining fight.

The fpinal marrow of the Mite confifts of twelve divifions, or, as it were, nodular fections. Thefe, however, are fcarce difcernible,

on

on account of their ſmallneſs, being no larger than grains of ſand. This part is inveſted with a moſt delicate coat, through which are ſpread a great many pulmonary tubes: it is beſides covered with particles of fat, which I have endeavoured to repreſent by dots on the figure of the marrow. All the nerves iſſuing from the ſpinal marrow are covered with a continuation of the ſame coat, which inveſts the marrow itſelf; and they are likewiſe furniſhed with pulmonary tubes, which accompany them in their moſt delicate ramifications.

The ſpinal marrow, viewed ſideways, has quite a different appearance from that which the figure here given of it repreſents; for, on looking at it in this manner, it appears ſituated lower than the brain, Tab. XLIII. Fig. VIII. *a*, and looks ſomewhat crooked, *b*. This form, I am inclined to think, was purpoſely contrived to allow a freer paſſage to the gullet, where it runs down, like an inteſtine, from the jaws to the ingluvies, or ſwallow. This is the reaſon why the brain is placed above the gullet, and the gullet, together with the ſtomach, reſts upon the ſpinal marrow, and its nervous ramifications: ſo that, properly ſpeaking, the ſpinal marrow reſts upon the muſcles of the rings of the body in the under part, and is cuſhioned up with particles of fat on every ſide.

The conſtruction of the muſcles, which in this inſect move the rings of the body, is very ſingular and ſurpriſing. I diſcovered three different kinds of them, without examining farther than the foremoſt part of the thorax; ſome deſcending obliquely with two bellies, Tab. XLIII. Fig. IX. *a a a*; ſome broad ones run croſſways, *b b*; and others again aſcend obliquely, *c c*. All theſe muſcles are ſo elegantly ſituated, that the greateſt adepts in deſigning and painting, I am certain, muſt confeſs their inability, were they to go about repreſenting them as they deſerve to be figured. To exhibit exactly every thing worthy of notice contained in theſe parts, we ſhould be obliged to make uſe of figures twenty times larger than theſe now before us. And, after all, the muſcles which I have called the obliquely deſcending, and which have two bellies, do not, properly ſpeaking, deſerve that name; for they appear to have five tendons, of which one is inſerted into the muſcle that lies next to it, and the other four into the tough rings of the body, which they ſerve to move, as I have endeavoured to repreſent, if the unſpeakable magnificence of God's works can at all be repreſented by human art. An infinite number of pulmonary tubes are diſtributed all over theſe muſcles; but, as yet, I have not been able to diſcover in them any inſertions of the nerves: ſo that I muſt, in this point, own myſelf as much at a loſs, as I have upon many other occaſions.

As to the heart, which ſends the white or aqueous blood of this little creature, in a due circulation, through the body, I could by no means diſcover it; and this I attribute to its ſmallneſs, and to its being of a thin and delicate ſtructure. But I am perſuaded, that it lies in the upper part of the back, like that of Silkworms; for I could plainly diſcern pulſations in that part.

An account of the manner in which Mites get into cheeſe, and cauſe it to rot, inſtead of being cauſed by or formed themſelves out of rottenneſs; with many other uncommon obſervations.

THE parts I have hitherto mentioned and deſcribed, are all I have been as yet able to diſcover in this minute inſect. And now let the ſharpeſt geniuſes, and men of greateſt penetration and learning, judge if a creature, in the fabrick of which there plainly appears ſo much art, order, contrivance, and wiſdom; nay, in which is ſeen the hand itſelf of the Omnipotent God; could poſſibly be the production of chance or rottenneſs! Is not the light of human underſtanding alone, unaſſiſted by divine revelation, ſufficient to convince us, that it cannot be ſo? Certainly it is ſufficient. The illuſtrious Redi as evidently proves, that this ſyſtem of the production of animals from putrefaction, aſſiſted, as they would have it, by heat and moiſture, is a mere idle imagination, founded on the erroneous maxims of heathen philoſophers, unacquainted with any ſuperior origin of exiſtence.

That ingenious naturaliſt moſt accurately explains in what manner Mites proceed from Flies, which have depoſited their eggs in the cracks and holes of cheeſes*: and I can add to his account, that the body of theſe Flies terminates in ſo fine a point, that they are able to thruſt it into, and penetrate very deep in, the ſmalleſt openings. I cannot but alſo take notice, that the rottenneſs of cheeſe is really occaſioned by theſe Worms; for they crumble the ſubſtance of it into ſmall particles, and void their excrements in it, and foul it with their ſaliva, or the moiſture of their mouths; ſo that the ſmalleſt ſpot of rottenneſs, produced by theſe inſects, cannot but immediately ſpread itſelf. I once obſerved a cheeſe, which I had purpoſely expoſed to this kind of Flies, in order that they ſhould lay their eggs in it, grow moiſt in a ſhort time, in thoſe parts of it where theſe eggs had been depoſited, and had afterwards

* This ſpecies of Maggot, though altogether different from what we call the Mite, is not uncommon in large cheeſes, particularly in ſuch as have not been well made, and have fermented. In ſuch cheeſe, where it is moderately ſoft and damp near the ſurface, theſe Maggots are frequent; and if they fall off, on being diſturbed, they will leap about, upon a diſh or table, in a ſurpriſing manner.

been

been hatched into Worms, though before the cheese was perfectly found and entire. I have likewife obferved, that this putrefaction in cheefe is confiderably augmented by the carcafes of the Worms that happen to die in it; for there always die fome of them: and it is impoffible there fhould not, as it is a certain death to them not to be able to harden into Nymphs, and all of them cannot efcape out of the moift part of cheefe to a drier fituation, which is neceffary to fuch a change. Further, I have obferved, that fome of thefe Worms contained other Worms within their bodies, but fo minute as to be fcarce difcernible. But, on extracting thefe fmaller Worms from their places, I found they were almoft of the fame form with the larger Worms, though they move themfelves from place to place in quite a different manner. I could even difcover, in the tranfparent bodies of thefe fmaller Worms, that, by examining with the microfcope, notwithftanding their almoft incredible miutenefs, they were furnifhed with pulmonary tubes, and other parts in common with the greater.

It is certainly very difficult to explain in what manner Worms are bred in living animals; as, for inftance, in the livers of Oxen, in the kidneys of Dogs, and even in the blood-veffels, as is obferved by that celebrated anatomift and profeffor of furgery at Amfterdam, Ruyfch. For my part, I freely own, that I want fufficient experiments to form any folution of this furprifing phenomenon; though I have met with great numbers of different kinds of Worms, in the living and healthy bodies both of land and water animals, and even of fowls and flying infects. However, on this occafion, I cannot as yet advance any thing certain, or fatisfactory.

I muft not omit a circumftance which I heard from Otto Marfilius, the late famous painter of flowers and infects. It was this, that he had feen, at the time when Caterpillars were bufy in divefting themfelves of their fkins, or when they had juft performed the operation, and were grown faint and weak with the fatigue of it, a great many Flies, fome bigger and others lefs, piercing the bodies of fuch Caterpillars, and depofiting in the wounds, fo made, quantities of little eggs; from which proceeded the Worms, that are every year fo commonly found in Caterpillars. As yet, I muft own, I never faw myfelf this ftrange operation: but allowing it to be fact, it would perhaps greatly help us in explaining the generation of Worms found in the vifcera, or bowels, of larger animals; provided efpecially fuch Worms were found afterwards to turn to Flies, or other winged infects, which as yet I have not been able to determine experimentally, notwithftanding the pains and attention I have beftowed on the obfervations of changes in this kind. Admitting Marfilius's account to be true, and that fome of the perforations he obferved were made into veins and arteries, and eggs were depofited in fuch perforations, there can be no difficulty in conceiving how the circulating blood might have difperfed thefe feeds of animals all over the body. It muft however be owned, after all, that thefe things are as yet buried in a cloud of darknefs, which obfcurity, nothing but the brighteft light of experiments can ever difpel. In the mean time, we may fee, by the manner in which we are affected by the ftinging of a Bee, how an animal, without getting into our bodies, may convey a matter into it, capable of producing great alterations; for the Bee, at the fame time that it gives the wound, infinuates by it into the body a drop of poifon. This is not a place for explaining how eggs come to be found in the fubftance of plants; befides, that I have already fufficiently treated of that fubject.

As to the opinion of fome people, that the Worms found in our inteftines proceed from the eggs of animals which we have fwallowed, it only deferves contempt, being altogether contrary to found reafon; unlefs the favourers of that fyftem would at the fame time allow, that the eggs fo fwallowed are thofe of Worms bred in the inteftines of other animals. This opinion cannot by any other means be admitted, as it is quite inconfiftent with the nature of things, that an animal fhould live for any time in a fituation fo different from that in which it naturally fhould live, and on fo different a food. Befides, for this to be true, it is requifite that fuch Worms, intended for living in other places, fhould alfo be able to endure the heat of the inteftines, and of the fluids paffing thro' them. A thing which no man in his fenfes can admit.

The generation of animals, or the laying and hatching of their eggs, is by no means a thing which requires little care or attention. Every creature has its own feafon, its own haunts and element, its own manner of living, and its own food. Every year we obferve the fame renewals of the feveral fpecies, performed in a manner limited by a conftant and inviolable law and order of Nature; as the illuftrious Redi, before mentioned, has, on another occafion, likewife obferved. For this reafon we always fee, that Worms of the fame kind, found in the inteftines of animals, have conftantly their blood of the fame colour, be it red, yellow, green, or white.

In regard to Caterpillars, indeed, I have obferved four different ways in which Worms lie hid within their bodies, and afterwards creep out of them *. The firft is, when one or more Worms make their way into the Cater-

* The cafe in thofe Flies, which we fee hatched out of Chryfalis's, from which we expected Butterflies, is exactly the fame with thofe produced from galls, and the other excrefcences of vegetables. The parent Fly is guided by inftinct to lodge her eggs in the body of the Caterpillar, piercing its fkin, for that purpofe, with a fharp inftrument at its tail. I have feen the operation; and the mifery of the Caterpillar, which can no way efcape from its winged enemy, is terrible. All the variation in number of the young, and other accidents, is owing to the different fpecies of the Flies.

pillar, kill it by their corroding, and afterwards make their way out again through, the ſkin. The ſecond way is, when two or three Worms lay hold of a Chryſalis, and, after killing the encloſed animal, eſcape in the ſame manner. In the third way, the Worms, after depriving the Caterpillar of life and motion, eat up all its inſide; and, this done, they bore or gnaw themſelves holes to creep out at in its hardened ſkin. Fourthly, when one or many Worms treat a Chryſalis in the ſame manner exactly, in which the Caterpillar is treated in the third way.

There are ſeveral other things to be conſidered in this place. Firſt, when the Caterpillar happens to be killed by a ſingle Worm, which afterwards fixes its reſidence between that creature's body and its web, then the Worm ſpins itſelf another white oval web, in which it changes to a Nymph, and afterwards to a Fly. But if the Caterpillar is deſtroyed, and perforated by a number of Worms, then theſe Worms ſettle themſelves under the belly of the dead Caterpillar; where each of them makes itſelf a gold-coloured web, in which they caſt their ſkins, then become Nymphs, and at laſt aſſume the form of Flies.

Secondly, when two or three Worms eat into a Chryſalis, and afterwards creep out of it, they do not, immediately after ſo doing, caſt their ſkins, but only contract their bodies: and while they are in this ſtate, they aſſume, in an orderly manner, and with a conſtant regular ſucceſſion, thirteen different colours; the laſt of which, alone, they finally retain. At laſt, they turn to Nymphs within their old ſkins, and then to two or three common Flies.

Thirdly, the Worm which ſingly takes poſſeſſion of a Caterpillar, and, after having eat up all its inſide, remains within the ſkin; ſometimes makes itſelf a web within this ſkin, and then becomes a Nymph, and at laſt changes to a Fly like the baſtard Waſp, Pſeudo-ſpheca, or Ichneumon-fly. In this caſe, we always find ſome excrements within the Caterpillar's ſkin; as likewiſe the two ſkins which the encloſed Worm has ſeverally thrown off, on turning to a Nymph, and then to a Fly. But the minute Worms, which remain in the Caterpillar they have deſtroyed, make no web in it; though they grow to Flies, in the ſame manner with the Worms producing that kind of baſtard Waſp juſt ſpoke of, and then gnaw themſelves holes to make their eſcape.

In the fourth place, the Worm, which remains ſingly in a Chryſalis, makes alſo a web within it, voids its excrements there, and then changes to a kind of baſtard Waſp, in the ſame manner with the Worm juſt now mentioned, as living ſingly within a Caterpillar. If you open the ſide of this emptied Chryſalis, before the encloſed Worm changes to a Nymph, it immediately ſpins a patch againſt the broken part. But when many Worms are placed together in a Chryſalis, they neither make themſelves webs, nor do they even contract themſelves, but only change to a great number of ſmall Nymphs, which afterwards turn to as many Flies. Theſe Flies, which are of a moſt elegant ſtructure, ſometimes gnaw themſelves one, and ſometimes more holes, for their eſcape, in the dried ſkin of the Chryſalis.

All theſe things proceed every year in ſo conſtant, certain, and regular a manner, that no accident whatſoever can alter the courſe of the operation. One very ſingular inſtance of this unchangeable order in nature, is, that even the Caterpillars and Chryſallides, which are to become the ſcenes of the laſt mentioned changes, may be eaſily diſtinguiſhed from the other inſects of the ſame kind. In the firſt mode of theſe mutations, when the Worms, which have lodged, many together, in a Caterpillar, place themſelves under its belly, the Caterpillar raiſes that part, to make way for them; and though, by this time, it has received its death's wound from thoſe cruel invaders, it notwithſtanding, with the greateſt care and attention, encloſes and connects all their particular webs, within one of its own ſpinning, for fear they ſhould be ſcattered abroad and loſt, and after this expires.

From hence we may reaſonably conclude, that if the Worms had thus lodged in the Caterpillar, and killed it, merely by accident, inſtead of doing both, in conſequence of an immutable decree of the All-governing Power, the Caterpillar, when it found itſelf ſo roughly treated by them, would by no means take this regular care to ſecure them from rain and winds, and thereby inſure the renewal of that particular ſpecies of inſects; for they generally turn to Flies the year following.

The ſame order is obſervable in all the other perforations, deſtructions, and excavations of Caterpillars and Chryſallides, which I have already taken notice of, ſo that we can only aſcribe to our own raſhneſs and ignorance that erroneous notion, of putrefaction being able to perform wonders worthy of the Deity, and to which the power of the Deity alone can be rationally deemed equal. It is therefore in the higheſt degree ſurpriſing, that all mankind, the learned as well as the ignorant, ſhould have ſo readily adopted, and ſo long entertained, ſo groſs an error; eſpecially as the leaſt degree of reflexion muſt have convinced them, it aroſe from prejudice; at the ſame time that the ſmalleſt diligence, in examining the works of Nature in themſelves, would have put them in the way of obtaining more juſt ideas on this ſubject.

Let us then be wiſer than thoſe who have gone before us, and accurately ſurvey and examine the ſenſible wonders of the Deity, with all their conditions and circumſtances, if we intend to obtain a true and ſolid knowledge of them. Let us not ſervilely ſubmit our judgments to the doctrine of Ariſtotle, and the reſt of the heathen philoſophers, who aſcribe to putrefaction, works that contain viſible marks of an all-perfect Contriver and Maker; tho' at the ſame time we are, as men, convinced by daily experience, and, as chriſtians, are taught to believe, that all the things we fee are liable to decay and deftruction. God's power and wifdom is not to be feparated from his juftice, fince, according to the unerring teftimony of his holy fpirit, he has entered into a covenant with his creatures; and thefe, under their corruption, groan and figh after liberty.

That vulgar opinion, more worthy of brutes than of rational beings, which afcribes the birth and growth of animals to putrefaction and chance, is diametrically oppofite to found reafon, and favours rankly of atheifm. It has not even the leaft fhadow of experiment or obfervation to fupport its truth; but is founded altogether upon floth, prejudice, ftupidity, and error; all which is the more obvious, as in the fmalleft animals we conftantly every where find as much order, contrivance, beauty, wifdom, and omnipotence in the Great Architect, as are fhewn in the vifcera or bowels of the largeft animals. For to thefe greater animals all others, however contemptibly minute, if their minutenefs can make them contemptible, are fimilar in the great refpects of brain, nerves, mufcles, heart, ftomach, inteftines, and parts fubfervient to generation, and to every other ufeful purpofe; fo that one might in a manner affirm, that God has created but one animal, though divided into an infinite number of kinds or fpecies, differing from each other in the figures and inflexions, and extenfions of their limbs; as likewife in their difpofitions, food, and manner of living.

As Caterpillars, which turn to Butterflies, often contain in them Worms which change to common Flies; fo the Worms, which change to Beetles, very often contain in their vifcera alfo certain Worms, that turn to Beetles of a fmaller kind: and, in thefe changes, Nature obferves the fame conftant order and method, as in the firft. From hence I again conclude, that nothing is produced by putrefaction; but that the bufinefs of generation unalterably proceeds in a certain and regular manner. And certainly, if our little philofophers would attentively examine what is the nature of putrefaction, when it breaks out in an animal, or in any part of one, which thereby rots, and is refolved into its conftituent principles; and would withal confider that fpecies of putrefaction which Worms occafion, and which they cannot but occafion, in other bodies, or in fome parts of their own; they would foon free themfelves from the yoke of fo abfurd and flavifh an opinion.

As yet, I cannot by any obfervation determine, whether the Mites, which are found to contain other Worms, are perforated by them, while they remain in the cheefe, or after they forfake it, and turn to Nymphs. It is only within thefe fix or feven weeks, that I have made the experiments concerning thefe infects, which I have juft now related, having never exprefly examined them before that time. However, in this time I could difcover in the cheefe a great number of dead and rotten Worms, of a red, purple, and livid colour, whofe carcafes not a little contributed to increafe the ftench and putrefaction of the cheefe in which they lay, and likewife the acrid and peculiar tafte found in fuch parts.

The manner in which Mites are changed into Nymphs *.

THESE Mites, when they are about to become Nymphs, generally defert the cheefe in which they had hitherto lived, by leaping up and down, till they find, if poffible, a more favourable fituation. In three or four days after this they loofe all motion, grow ftiff, and harden. I have remarked alfo, that the change of thefe Worms may be forwarded by enclofing them, when well grown, in a dry box, without any thing to feed upon. In trying this experiment I have obferved, that fome fmaller Mites remained alive in this confinement, without any food, for two or three weeks together; when they at length died, without turning to Nymphs; the embryo member hid under their fkin not having attained the growth and firmnefs requifite for that ftate, which is obtained by the reft in the following manner.

Firft, the Mite draws up together the rings of its body, fo as to make the interftices appear full of wrinkles; and this contraction is fo great, that the Worm becomes twice as fhort as it was before, Tab. XLIII. Fig. x. This alfo renders the rings lefs difcernible: however, the fore part of the head, Fig. XI. *a*, may be ftill diftinctly perceived, as well as the tubercules, *b*, at the other extremity of the body. As to the form of the little animal at this period, it fcarce affords any thing worth particular mention; for the fkin lofes its tranfparency. In this ftate the Worm gradually changes its colour, till from white it becomes red, and in the end refembles pure red lead.

The moft experienced naturalift fignior Redi, who has favoured the world with a fhort hiftory of the Mite, tells us, that its mutation agrees in nothing with that of Chryfallides, and other Nymphs, but he does not acquaint us wherein they really differ. Other authors confider Mites at this period as eggs, though they have no other reafon for thinking fo, than a bare fuppofed refemblance. This indeed, is fo far from being even a fuperficial one, in proper terms, that it can only be found in their own extravagant imaginations.

* Let the reader be cautious not to extend what is here faid of the Nymph of the Mite, and its change into a Fly, to the common little infect, ufually called a Mite by us; that is, an infect which is hatched perfect from the egg of its parent, and undergoes no change, but only grows larger. This ftate of change belongs to the offspring of all winged infects, and to no others. Therefore it is neceffary, according to the univerfal law of Nature, that this Maggot fhould undergo fuch a change, and that the Mite fhould not.

They

They pretend to fee things, which never exifted, and they well deferve to be compared to thofe perfons, who, fometimes, with equal truth, think they difcover armies in the clouds, which were never formed but in their own difturbed imaginations.

For my part, I call this change, by the name of the Vermiform-Nymph; becaufe, in this ftate, the creature externally refembles a Worm, and is at the fame time really a true Nymph, and not a Chryfalis, under the former Worm's fkin, which it ftill retains together with the internal figure of a Worm. And accordingly, the limbs of a latent Nymph, appear, in fome meafure through, to a careful examiner, this fkin. But I have already fufficiently explained this fourth order of mutations in its proper place.

The Nymph, thus concealed under the fkin of the Mite, is of a moft elegant form. But to have a diftinct view of it, 'tis neceffary to break this fkin, and then ftrip it off from the Nymph. This muft be done with great dexterity and circumfpection. By this means, we at laft obtain a fight, and a beautiful one it is, of the head, thorax, and abdomen of the future Fly, as I have reprefented them of their natural fize, Tab. XLIII. Fig. XII. But to perceive them diftinctly, we muft ufe a microfcope; with the affiftance of that ufeful inftrument, we difcern its two little horns, Fig. XIII. *a*, growing out of the forepart of its head, and under them its two eyes, *b b*, which take up the greateft part of the head. Under the eyes lies the probofcis or trunk, *c*, with all its parts. Near the probofcis appear the firft pair of legs, *d d*, and under the firft pair the fecond, *e e*, difpofed in a very beautiful order. The rings neatly folded up, *f f*, prefent themfelves next, and under them, we may fee in what manner the hinder pair of legs, *g g*, lie ftretched againft the abdominal rings of the body, *h*: thefe, with the extremity of the anus, are very diftinctly to be feen. In fine, all thefe parts are arranged together, with fo much art and beauty, that it is impoffible to give a juft defcription of them. They will be feen yet a great deal more diftinctly, by divefting the Nymph of the fkin that immediately enclofes it.

At firft all thefe parts are of the colour of coagulated milk, but as fluid as water, which makes it very difficult to feparate them; nor can they, after all, be accurately diftinguifhed one from another, becaufe they are at this period, all of the fame colour. In ten or twelve days, they acquire fo much confiftency, and fo much of their peculiar colouring, as to affume the form of a complete Fly, on throwing off the internal membranes that cover them, within the former Worm's fkin, which they ftill retain for twelve days longer; when the new infect, having acquired fufficient ftrength to appear abroad, breaks this external enclofure likewife, and launches into the air, in the following manner.

The manner in which the Nymph of the Mite breaks from its membranes, and affumes the form of a Fly.

THE firft thing obfervable in this change is, that the Vermiform-Nymph lofes its deep red colour, and grows much darker; then the Nymph itfelf breaks that part of the fkin, which covers its head into two parts, Tab. XLIII. Fig. XVI. *a*, *b*, and at the fame time throws off from every part of its body a very flight membrane, which it leaves within the old fkin. When this is done, there breaks out from under this fkin, a little infect like a gray Fly, without wings, but fo nimble, that it runs immediately about as if it were feveral weeks old.

Sometimes after this, the new born Fly rubs with its forefeet, that part of its head which lies immediately over its horns; for, on this fpot, there arifes a confiderable fwelling, with a violent pulfation in it. The Fly never gives over rubbing, till it has difperfed the fwelling, and made it entirely difappear. 'Tis probable, that it was in this part, the fore-legs lay while the infect remained in the Nymph-ftate. The next thing the Fly does, is to rub very gently with its hinder-legs, the furface of its two fhort little wings, which are as yet folded up, till it thoroughly expands, and difplays them. This operation may be very diftinctly feen, and I have reprefented the great folds, Tab. XLIII. Fig. XIII, *f f*, which the infect thus expands. The Fly, after this labour, takes a little reft, remaining quiet until the wings fully difplay themfelves, which is performed very fuddenly, for their veficles are no other than ramifications of the windpipe, which run up and down through them; fo that we may eafily conceive how they may be fo fuddenly expanded by an injection of blood and air from the main trunk. The infect, however, cannot as yet fly; its wings yield fome blood if they be wounded at this time; whereas, when they are once perfectly dried, which is done in a quarter of an hour, it is impoffible to obtain the leaft drop of blood from them, even by cutting them off, the veffels being in that time perfectly dried up and clofed; for my part, I firmly believe that all the membranes of animal bodies are no other than a kind of webs, confifting of veffels confolidated in this manner, as may be feen in the blood-veffels of the epidermis, which dry up as foon as the fœtus comes from the womb, and ceafes to draw nourifhment from that part of its covering.

The Fly produced from the Mite is one of the common kind; and it affords very few things worth our notice: this may be feen by the two figures, in which I have reprefented it of its natural fize, Fig. XIV. The wings, when they lie on the body, extend beyond the extremity of it. I give alfo a figure of the male, after a drawing taken with the microfcope, in which the head, thorax, and abdomen are feen very diftinctly. On the forepart of the head, there arife two fhort horns,

horns, Fig. XV. *a*, each with a ftiff hair growing out of it. Near the horns appear the eyes, which are red, pretty large, and of a reticular net-like form; between the eyes, there ftretches along the middle of the head, a black zone or prominent ftreak, in which are placed three feparate and diftinct eyes in the form of a triangle. Thefe are much more difcernible on the Fly's firft appearance in the air, than afterwards, as the ftreak or zone juft mentioned requires fome time to grow black, and has, befides, fome hairs on it, which do not erect themfelves, till, by drying, they become fufficiently firm for that purpofe.

The thorax is covered with ftiff hairs, of a brown colour, but of a polifhed and fhining furface, like a looking-glafs. From its lower part rife fix legs: the firft or fore-pair of them, *b b*, are almoft black: in the fecond pair only, the joint near the breaft is of this colour; and the other two extreme joints, *c c*, of a dark brown. The third pair, *d d*, very nearly refemble the firft: but thefe colours are not exactly the fame in all the Flies of this fpecies. All thefe legs are covered with ftiff hairs, and are each of them armed at their extremities with two claws, by means of which the infect runs very nimbly upon glafs, by darting them into the pores of it, not but that it can walk very well when thofe nails are cut off; but then, though its feet are moift, it cannot hang itfelf to fo fmooth a furface. The wings are two; they are of a beautiful conftruction, and arife from the flope of the breaft, *e e*; they are bordered with fine hairs, and the filaments which run through them like fo many little nerves, are no other than ramifications of pulmonary tubes. The membrane which fills up the fpaces between thefe ramifications, is likewife elegantly conftructed: it is covered with little prominent papillæ, but a drawing ten times larger than this, would hardly be fufficient to do juftice to this and other wonders, difcoverable in the wings of flying infects. The hinder part of the thorax is, by way of ornament, furrounded with a little prominent border; near which appear two very fmall oblong particles, with round heads, refembling mallets or hammers: it is by ftriking thefe little hammers againft its wings, that the Fly makes the humming or buzzing noife that is peculiar to it *.

The body confifts of feven rings; it is covered with delicate hairs, *f*, and is of the fame refplendent dark brown colour with the thorax.

The female differs from the male externally, in nothing but fize: but the genital parts of the two fexes are very different, as I fhall now endeavour to demonftrate.

Of the genital parts of the male and female Mite-Fly, and the manner of their coupling.

THE Mite has a penis, two tefticles, feminal veffels, and proftatæ; and the female its ovary, its womb, and the parts naturally belonging to it. The penis of the Mite is fo artfully contrived, that the feven wonders of the world together, cannot compare with it; nor is it furprifing they fhould not, they being the works of men, whereas this little organ is the conftruction of an Almighty and all-feeing Architect. It is partly membranaceous, and partly of a fubftance between bone and horn; the length, and inflexions of it alfo, are fo uncommon, that it is impoffible to confider it, without being loft in aftonifhment.

That part of the penis, which confifts of a fubftance between bone and horn, is black, and extends only along one fide of it, Tab. XLIII. Fig. XVII. *a*; but this is enough te give the penis great ftrength and firmnefs, and to keep it always open, in readinefs to perform its duty. The other fide of the penis is membranaceous, *b*, and confifts of many tranfparent rings and globules. The fore-end of the penis is alfo membranaceous and obtufe, *c*, though I have fometimes feen it pointed with fomething like an articulation at its extremity. It generally, however, appears blunt and open. I cannot tell whether or no the penis can erect itfelf through this opening; but I know of a certainty, that the vulva of the female paffes into the faid opening, fo as to form a kind of copulation, quite different from that of other animals, in which the penis is received into the female external organ of generation. It was by meer accident that I difcovered this fingularity in the copulation of the Mite-Flies: on examining a female, which had died for want of food, in the very act of copulation, I found the penis of the Mite withered round the vulva of the female, where it had been applied; but was then fo loofely engaged, that I eafily feparated them.

The penis lies on the outfide of the body, and is very eafily difcerned, as it extends along the body, with only its right fide covered by the laft ring. It is elegantly coiled up, and refembles very much the penis of Drakes, which is likewife folded up in the fame manner. This bird, it feems, does not ejaculate its feed through any perforation within the penis, but by a furrow or channel on its outfide. This I have likewife found to be nearly the cafe in fome other animals.

The other parts of the male Fly fubfervient to generation, are likewife very well worth our attention, but they lie hid within the body. The firft that offers itfelf to our confideration, is the nervous root of the penis, *d*, which is of a very bright white, and reaches to the laft ring of the infect's body, where the external part of the penis is covered with very fine hair. This white

* The French call thefe two parts Balanciers, Balancers; and their fyftem is, that they affift in flying; and in fome meafure make amends for the want of another pair of wings. There is probability in this opinion, becaufe all two winged Flies have them; and none that have four wings. Thefe fyftems are not contradictory, for they may anfwer both thefe purpofes.

root of the penis is bent in a very wonderful manner, and grows broader at its extremity, *e*, where it unites with feveral other parts, amongft which the tefticles *ff* deferve our particular notice, on account of their fingular figure and conftruction. They are of a pale brown colour, variegated with red; but the fperm contained in them is white, and that, as well as the coat of the tefticles, appears thro' the microfcope, as if made up of little globules. The vafa differentia, *gg*, next prefent themfelves. Thefe veffels widen confiderably at a little diftance from their union with the tefticles, and refemble, as it were, the two globofe appendages of thefe parts, *hh*. There is fo little difference between the other parts, that I cannot diftinguifh them from one another, though I take the longeft of them, as appears by my drawing, *ii*; for the feminal veffels, and the others, which are more globofe for the proftatæ, *kk*. All thefe parts are of a delicate whitenefs, and they convey a feminal matter of the fame colour to the cavity of the penis. Thefe are all the parts I have examined in the male Fly, as it was the Worm alone, of which I propofed to take a full and accurate furvey.

The female, on the other hand, is furnifhed with a double ovary, conftructed nearly in the fame manner with that of Herrings. But I fhall defer fpeaking of thefe organs, till the external parts of the uterus are defcribed. The female hides its vulva, and the extremity of its uterus, under the two laft rings of its body, Fig. XVIII. *aa*. The vulva confifts of three joints, the firft of which is oblong, and hairy at its extremity, *bb*, and is furnifhed in the middle with two little black horny bones, which help greatly in the protruding of this organ out of the body. The fecond joint lies entirely within the firft, as within its prepuce. It is naked, or free from hairs, and it ends in a horny bone, *cc*. The laft joint, which, properly fpeaking, conftitutes both the vulva and anus, is perfectly black, and is compofed of a horny bone, and a membranaceous fubftance, with here and there a few hairs, *d*. Thefe parts of the Fly generally hang out of its body, on its quitting the Nymph-ftate, in order that they may dry to a proper confiftency; they then void a drop or two of a fluid, which looks like water mixed with chalk. The excrements afterwards, thrown out from thefe parts, look little balls with tails to them, and confifting of a fubftance that very much refembles plaifter of Paris.

In diffecting this Fly, I found it contained an ovary divided into two partitions, each confifting of thirty-two oviducts, with four eggs in each, one pretty large, Fig. XIX. *a*. and three imperfect ones *b*; fo that the ovary of this fingle little creature contained no lefs than 256 eggs. Thefe eggs were white, oblong, and crooked; the colour of the fmalleft was watery. When viewed with a microfcope, they appeared to confift, as it were, of little globules, and the oviducts fhewed themfelves in the fame manner. All thefe oviducts difcharged their eggs into the uterus by two common paffages, and the uterus conveyed them out of the body by a fingle channel. I furveyed the other vifcera, or entrails lying thereabouts, but very flightly; fo that I could only fee that the fat that had exifted in the Mite, was now almoft totally wafted away, and that the inteftines formed a great many more folds than they had formerly done, though they were grown confiderably fhorter, and lay now entirely on the abdomen. Nor were the eggs yet perfect, tho' the Fly I diffected was four days old.

Flies are by nature of a very warm and luftful conftitution; fo that the female, immediately after its firft appearance in this form, and before it has changed its gray colour, invites the male to copulation. In this act, which lafts for a confiderable time, the male always gets upon the female; and in this fituation he is carried by her up and down like a man on horfeback. All this time the female keeps her wings expanded, and extending her vulva to that part of the male's body, where the penis lies, thrufts it into the cavity of this organ, which does not, upon this occafion, fuffer any erection. And this manner of copulation obtains in many other kinds of Flies, and likewife in fome kinds of Hornets. It is very fingular to obferve how the male gently pats the female during this operation with his body, and preffes himfelf upon her juft as a Cock does with the Hen, tho' the copulation of thofe fowls is very fpeedily performed, and that without any abfolute corporal conjunction.

The Flies under our confideration, are very ftout and vigorous; fo that it is no eafy matter to deftroy themby drowning: after lying in the water a confiderable time, fo as to appear quite deftitute of life and motion, they will immediately recover on being expofed to the fun, and fly off as brifkly as if nothing had happened to them. They have two methods of flying; in the one their motion is flow and regular, and in the other it is rapid and diforderly. I fed fome of thefe Flies with new milk-cheefe fteeped in water, which they fucked up thro' their trunk, or probofcis. This ufeful and curious organ is placed on the lower part of the head, a little below the horns, or antennæ, and it confifts of three hairy joints. I likewife had the pleafure of feeing them lay their eggs in a piece of cheefe, and I found in a few days afterwards a number of Worms which had fprung from thofe eggs, perfectly refembling thofe of the firft brood that had produced the parent-fly.

The

The manner in which these Flies lay their eggs; with an account of the membranes they throw off on leaving the Nymph-ſtate.

IT appears, at length clearly, by what I have obſerved concerning theſe inſects, how readily the females can lay their eggs in the ſmalleſt cracks of a cheeſe; and I have ſeen them myſelf thruſt out their tails for this purpoſe, to an amazing length, and by that method bury the eggs in the deepeſt cavities. Theſe eggs in time produce Worms, which afterwards turn to Nymphs, and then to Flies: and this buſineſs conſtantly proceeds according to the immutable decrees of providence, in one uniform circle of production, without the leaſt variation in time or place, unleſs it be when the Flies cannot find cheeſe to receive their eggs, for then they look out for ſome other kind of food, as much reſembling cheeſe as poſſible, in its nature and qualities. Thus has this ſpecies of little creatures been kept up from the time of Adam to our days, thro' a ſucceſſion of many thouſand generations.

After having made the obſervations already related, I thought it worth my while to examine the ſkin which is ſhed by this inſect, on its appearing abroad in the Fly-ſtate; and upon inſpection, I found that it contained a very delicate tranſparent membrane thrown off at the ſame time. In this membrane I could diſcern a great many of the pulmonary tubes which had likewiſe peeled off from the body; and what was ſtill more ſurpriſing, the ſnout of the Worm, with its teeth or claws, remained entirely with it. Theſe unſeemly organs, with which they heretofore uſed to crumble and take in their unſavoury food, and to run about and burrow in their putrified habitations, are no longer neceſſary in the Fly-ſtate. Theſe creatures have, inſtead of them, a trunk or proboſcis, by means of which they ſuck up the ſweeteſt juices, and a pair of ſwift and beautiful wings, wherewith they ramble at pleaſure thro' the untainted air, and raiſe themſelves far out of the reach of ſtench and putrefaction.

I heartily wiſh you, illuſtrious friend, a ſimilar change and reſurrection, of which that now we have been conſidering, ſeems to be an earneſt; for I am firmly perſuaded, that by treading courageouſly to the end of this mortal life, in the footſteps of our Divine Maſter, we ſhall then change it for a better; and lay down this corrupt body, to which we are now confined, in order to aſſume a far more perfect one. God, the giver of all good things, grant us this neceſſary perſeverance, thro' the infinite merits of his only Son, our Lord and Saviour. Amen.

The End of the ſurpriſing hiſtory of the Acarus, or Mite, and the Fly produced from it.

The hiſtory of the Worms found in the tubercles and ſwellings of the leaves of the Willow.

PART I.

AS in enumerating the Inſects which belong to my fourth order of changes, I have aſſigned there the place for all thoſe Nymphs which are found encloſed in fruits, tubercles of plants, trees, and their leaves; I ſhall now propoſe ſome of thoſe Nymphs, by way of a particular example. In treating of the Worms found in the tubercles of Willow leaves, I ſhall deſcribe the Tubercle itſelf, the Egg, the Worm, its Web, the Nymph, and the Fly.

The warts or tubercles of the leaves of the Willow, Tab. XLIV. Fig. I. are ſo obvious to the view, that there would be no neceſſity to deſcribe them, provided each of us had the ſame ardent deſire, and equal curioſity. But as all men are not delighted with the ſame thing, the moſt common objects in nature ſometimes remain unknown, and affect the ignorant with a rapturous admiration. For this reaſon, I ſhall briefly, in this place, explain the conſtruction, figure, colour, ſituation, bigneſs, tenderneſs, hardneſs, and ſmallneſs of theſe tubercles.

That the conſtruction of the ſeveral ſwellings that are obſerved in the leaves of the Willow trees may be diſtinctly known, we muſt firſt conſider particularly the leaf itſelf on which they are found. The leaf of the common Willow conſiſts of three coats; the internal as well as external, are very thin, and are ſet with light hairs, or a kind of down; but the middle coat is nervous and fleſhy, if I may be allowed the expreſſion; ſince the nerves, or rather the veſſels which convey the nutritious juice to the leaf, are placed in that part. Theſe veſſels are, indeed, extremely numerous, and are divided into ſo many ſcarce viſible branches in this coat, that they may be properly called the parenchyma, and compared to the fleſhy ſubſtances in the viſcera of animals: this may be ſeen moſt diſtinctly in thoſe kinds the leaves of which are thick and ſpungy.

The outward coat, or external ſide of the leaf, I call that part wherein the nerves or ribs are prominent, Tab. XLIV. Fig. I. *a.* beyond the reſt of the ſurface: the external or outer coat, and the inner coat, or inward ſide, I call that part of the leaf which exhibits theſe nerves, not ſo diſtinctly conſpicuous *b b.* Between theſe two coats the tubercles of the leaves, whereof we are treating, are ſituated, and

and they are nothing elſe but the dilatation, or more remarkable, yet irregular excreſcences of the inmoſt and nervous part of the Willow leaf. Theſe tubercles, therefore, are properly compoſed of a collection of the very fine veſſels of the leaf, which, concreting together into a maſs, form an extuberant little knot; to which the two coats of each ſide are ſo ſtrongly joined, that they cannot, but with difficulty, be ſeparated; nay even, theſe too are ſo much dilated by force of the tubercle, as to loſe their down or hairs in that part.

The external figure of theſe verrucæ, or tubercles, is very irregular: they are ſometimes roundiſh or oval *c*, ſometimes oblong *d*, and they are wrinkled *e*, ſmooth, and of many other ſurfaces and forms. Their internal ſtructure conſiſts, as it were, of little grains, reſembling broken free-ſtone of a large grain, and is filled with ſmall chinks and corners, viſible only with a microſcope.* The outward ſurface is of a (ſometimes faint, and ſometimes full) green colour, and is variegated with purple, red and yellow, all together or ſeverally: there are likewiſe ſome ruſty, ſmall and blackiſh ſpots obſerved in ſome of them, which are like marks of vermiculation *f*. Theſe tubercles are within of a full green, and at the ſame time ſomewhat yellowiſh here and there: this yellowneſs probably ariſes from hence, that the Worm hath conſumed the inward ſubſtance about thoſe places.

Theſe warts occupy various parts of the leaf: they are ſometimes found *g* in the middle region, adjacent to the nerve; they lie *h* ſometimes near the extremity of the leaf; ſometimes they are on the nerve *i*; ſometimes more ſwollen or depreſſed, and again are ſituated at a greater or leſs diſtance from each other; and therefore nothing certain or regular can be determined, in this reſpect, about them. They are conſtantly extuberant beyond the ſurface of the two coats of the leaf: but in that ſide of the leaf where the nerves run, they commonly project more than in the inward ſide; tho' I have found ſome which roſe to an equal height on each ſide *k*. I have likewiſe ſeen ſome which occupied the footſtalk of the leaf *l*; but theſe were fewer.

There is great difference between the warts, in regard to bigneſs and ſmallneſs, and alſo with reſpect to their greater or leſs number. In ſome leaves there are ſeen only one or two, in others ten or twelve. They differ alſo greatly in ſize. The reaſon of which is, that ſome of them are riper than others; or they are older, or have begun to increaſe afreſh. I ſhall hereafter treat of this matter in the hiſtory of the egg, and ſhall then likewiſe deſcribe their hardneſs and tenderneſs.

When I opened ſome of thoſe warts of theſe leaves, on the 14th of June, I met with quite different things therein. In ſome, which were ſhut very cloſe, I found a Vermicle, or Worm, like the Caterpillar of the Bindweed, together with its excrements, and a caſt ſkin near it. In another, which opened outwardly, with a round or orbicular orifice, I found another Caterpillar, of the ſame ſhape with the former, but conſiderably larger. In others that were not perforated, and ſtill contained their Caterpillar of the ſame kind within, I obſerved this was ſuffocated, or had been killed, by ſome other Worms, which likewiſe lodge themſelves in the warts. I obſerved that the rain had fallen into ſome others, that had holes, and were deſtitute of an inhabitant. In others again I found other inſects, which had caſt their eggs there. Nay, I ſometimes found the little caverns of theſe tubercles occupied by ſmall Spiders, which had ſhut up the orifice with one of their webs. I ſhall treat of all theſe things more particularly hereafter.

Theſe differences, obſervable about one and the ſame kind of tubercle, may, no doubt, lead ignorant perſons into error. Indeed, I am firmly perſuaded, that all who apply themſelves to experiments will be deceived, unleſs they thoroughly inveſtigate them, and endeavour to find out their firſt principles. Wherefore, as I had at different times obſerved what is before related, I have again, at length, examined theſe excreſcences with all the care poſſible. And thus I have, at length, diſcovered the real eggs out of which thoſe firſt Caterpillars, which I ſaid I found in the tubercles, are produced. At the ſame time alſo, I diſcovered the reaſons why other inſects alſo go into theſe warts.

On the ſaid 14th of June, I opened a great number of tubercles, of all kinds and figures: in the ſmalleſt of them I found real and perfect eggs, ſo circumſtanced in every reſpect, as if they had been laid there by the inſect. The leaf of the willow, in which I found ſuch an egg, had but very lately budded, and was ſtill tender, though it had obtained its full ſize and form. I found in this leaf the rudiments of ſeven ſuch excreſcences, which I repreſent in each ſide of it, Tab. XLIV. Fig. I. *m*. Some of theſe were a little larger, others ſmaller; but the minuteſt of them were ſo ſmall, that they could be obſerved only by reaſon of the ſmall change which was obſerved in the colour of the leaf. The largeſt of the tubercles, which began to ſwell a little, were of a yellowiſh green colour; but the ſmalleſt of all, which did not yet project beyond the ſurface of the coats of the leaf, was diſtinguiſhed from the leaf itſelf only by a paler yellow colour.

We muſt here obſerve, that the egg was alſo ſmaller in the ſmalleſt than in the largeſt excreſcences; in which I conſtantly found it much larger, and more advanced and forward. This egg was of an oblong figure, Fig. II. *n*, without any rings, having one end thicker,

* Theſe tubercles and warts, like galls, and the tufts on the dog-roſe, all ariſe from the punctures of inſects; and as there are many kinds of theſe inſects, it is not ſtrange that the tubercles are of various forms. They are all produced by wounds, at which the eggs of the parent-animal are introduced; and the young Worm conſtantly appears within them. Theſe Worms are, in general, very weak and defenceleſs; and this ſeems a proviſion of nature to hide them from their enemies.

the other more acute. It appeared tinged with a watery colour, and had an extended ſmooth ſurface. Theſe eggs lay looſe and diſengaged in theſe tender tubercles. There was no particular little cell; but they were every where equally ſurrounded with the inner ſubſtance of the tubercle. But when the wart afterwards becomes larger and harder, and by degrees loſes its ſtiffneſs and tenderneſs by accretion, then it is obſerved, that it inſenſibly opens on the inſide; and in proceſs of time is divided, as it were, into two diſtinct parts: in one of which only an egg is placed, Fig. I. *o*, and is gradually increaſed and augmented.

About that time one may very diſtinctly ſee, that the egg is no where fixed or annexed to any thing, nor has any veſſels, filaments, fibres, or any other ties, by the help of which it may cohere with the wart, and receive nouriſhment from it. Indeed, it never has any certain place in the tubercle; for it is ſometimes fixed in this, ſometimes in that ſide: it is ſometimes in the middle: it is ſometimes at a greater or leſs diſtance from the chink, which is naturally obſerved in the body of the tubercle. There are as yet no excrements found in the wart; but all things appear pure and clean.

It is very certain, that this egg is then in a ſtate of nouriſhing; for one may plainly ſee, that it is conſiderably increaſed, from time to time, and augmented. But the moſt obvious ſigns of this are obſerved chiefly in thoſe Worms which are a little older; for in ſuch the fore part of the egg is conſiderably ſwollen, ſo that even the head and two eyes of the Worm or Caterpillar, encloſed in it, are gradually ſeen through its integuments, and are obſerved, Tab. XLIV. Fig. II. *p*, to grow continually blacker.

If therefore it be aſked, how this egg is nouriſhed? I anſwer, it may conveniently have all neceſſary food from the effluvia and tranſmitting liquids, which perſpire into the cavity of the divided and broken excreſcence, and likewiſe may eaſily penetrate the coat whereby the egg is inveſted; ſo that they may be ſucked in, and ſwallowed by the Worm that lies within. All membranes ſerve to illuſtrate what I have here aſſerted; for theſe being put into a damp place, are likewiſe affected by the moiſture: but when they are ſuſpended wet in the air, or are expanded, again they exhale, by a contrary action, all the moiſt humours which they contain. Nay, it is plainly ſeen that gum tragacanth, though tied up in a membrane, is notwithſtanding conſiderably ſwollen, when put in a moiſt place. But here it deſerves particular notice, how powerfully ſalt of tartar attracts water to it. In the roots of trees and herbs, wherein open pores are not yet demonſtrated, no other mode of nutrition can indeed obtain or prevail. However this matter be, I think the juice, perſpiring from the ſubſtance of the warts, feeds the Worm that is thus contained within it.

Now, as an egg is nothing elſe but a Nymph encloſed in the pellicle, not yet having the firmneſs and ſtrength neceſſary to break open this coat with which it is ſurrounded, one may eaſily comprehend how the Worm, ſtill contained in the ſhell of its egg, may ſuck the nutritious juice which penetrates into the cavity of the egg. And indeed this obſervation, by which it is evident that the egg is nouriſhed, and becomes bigger, whilſt it is and remains an egg, moſt ſtrongly proves, that the egg is really the inſect itſelf; nor is there any other difference between this and that, only in reſpect of the inveſting coat, which prevents our ſeeing the contained inſect; though, in ſome caſes, one may diſtinctly enough obſerve it tranſparently through the ſkin of the egg. The egg, of which we treat in this place, is, in this reſpect, different from thoſe of many other inſects, becauſe the latter never increaſe, but for ſome time only cover the contained little inſects; juſt as the membranes of the Nymphs ſurround or environ the encloſed inſects for a time.

When this little creature afterwards has broken out of its egg, it has the form of a thin and ſmall Caterpillar, and is twice as long as the egg wherein it had been hid a little before. It is then always found within the tubercle, that the ſkin caſt off by the little inſect lies near to it. This little Caterpillar is at this time ſo ſmall, that, if it were delineated according to its natural ſize, it would ſcarce be as big as a point: wherefore I repreſent, Tab. XLIV. Fig. I. *q*, it rather at its full maturity, as it appears when it hath bored its way through the tubercle, and crept out through the hole *r* it made.

This little Caterpillar properly belongs to what are called the Bind-weed kind. If you view it with a microſcope, you will ſee it compoſed of fifteen annular inciſions, which conſtitute the head, thorax, abdomen, and tail. The head is of a raven-black colour, and exhibits, Fig. III. *s*, the eyes placed on each ſide. In the fore part, in the lower region of the head, are ſeen two hard horny or bony jaws; the extremities of which are divided into many ſmall ſharp-pointed teeth. With theſe the inſect, when provoked, is not afraid to bite even at a ſteel-needle. Theſe teeth are of a browniſh red colour, and tranſparent ſubſtance. The ſix firſt legs, *t t*, each of which conſiſted of five joints and one claw, were articulated with the three foremoſt rings of the thorax. The two rings immediately following had no legs affixed to them. But twelve other legs, Tab. XLIV. Fig. III. *u*, adhered to the lower part of the ſix rings of the body. Finally, the tail was alſo furniſhed *x* with two: ſo that this inſect has in all twenty legs. In the poſterior part of the head, and in the neck, as alſo about its tail, there are ſome black ſpots. This Caterpillar, like the Coſſus, or Worm of the Beetle, had a wrinkled ſkin, here and there ſet with hairs. It twiſted and gathered together the poſterior part of its body, like the Bindweed Caterpillar. It did not frequently make uſe of its middle, or laſt feet, except when

when it endeavoured to wind and twift the pofterior part of its body about the extremities of leaves; for then it faftened itfelf in the place with its feet, making no ufe of its fore legs at the fame time. When it walks, it ufes only the fore legs, and then draws after them the hinder part of its body. This is likewife the cafe in regard to the Caterpillars, before mentioned, which have many legs; and which likewife change into Butterflies fo conftantly, that I have hitherto obferved no example to the contrary. The points of refpiration were feen to open in the furface of the body, and the pulmonary tubes were tranfparent through the fkin. In the hinder part of the body, the heart fhewed itfelf alfo, beating.

While thefe little Caterpillars are fmall, they are of a colour mixed of a yellowifh white and pellucid green, which by degrees improves and grows ftronger. Even while they are, as it were, ftill in their cradles, a narrow line of a deep green colour, which denotes the aliment contained in the ftomach, is feen through their fkin; and this becomes of a more and more dufky green, the more the Caterpillar approaches to maturity; and the Caterpillar itfelf then alfo gets a much greener colour all over, only that it continues of a yellowifh white about the belly. Thefe little creatures feveral times change the fkin within thefe warts, and grow whitifh for a time, on cafting it.

The inner fubftance of the wart is their food, which they immediately begin to eat, as foon as they come out of their eggs. About that time their excrements alfo are found in the tubercles; and there is the greater quantity of them accumulated, the more the Caterpillar is grown. I have fometimes found fo great a quantity of thefe excrements in the tubercles, that it was three times bigger than the body of the infect. This principally proceeds from rain, which fwells thefe feces, and fometimes kills the little Caterpillar. This moft commonly happens, when it has already bitten through and perforated the coats of its wart, or tubercle. Thefe habitations are commonly pierced through by the Caterpillars, when thefe infects are arrived to their full fize; for then they always eat a hole through their tubercle, and then thruft the hinder parts of their body through the hole, fo that they may caft out their excrements, Tab. XLIV. Fig. I. *y*. The Caterpillars behave in this manner chiefly in rainy weather; for then their excrements fwell vaftly by the force of the wet, and would occupy too large a fpace, being otherwife not bigger than fmall grains of fand.

In procefs of time the whole fubftance of the wart is fo cleanly eaten out by the Caterpillar, that abfolutely nothing remains of it but the two outmoft coats of the leaf. After this the creature ceafes to eat, though it fometimes alfo abftains fooner. It is indeed very worthy of confideration, that the Worm in this excrefcence finds its aliment in fuch plenty, that it is never in want. On June 29, I obferved that many of thefe Caterpillars had crept out of the mouths or orifices of the verrucles, or little warts; nor could I, notwithftanding, find any of them either on the tree, or under it on the ground. In another tubercle, which I then opened, I found a dead Caterpillar. In another, the little creature had been entirely confumed, its remains refembling only a thin fkin; and near it lay a Worm without legs, which had probably confumed the entrails of the Caterpillar, and afterwards had crept out of the tubercle, in order to undergo its proper change. As I had unluckily given this Worm a little wound, I could not further profecute its changes. I fhall not prefume to affirm, as a certainty, that the vifcera of the dead Worm were confumed, or had been pierced, by this creature.

In order to inveftigate further what is done by thefe little Worms, I brought fome leaves and little branches of Willow-trees into my chamber, and there put them in moift fand. But fo it happened, that the Worms of thefe, having quitted their tubercles, got into the fand out of my fight. As I imagined it was the want of food that made them leave their abode fo quickly, I put fome leaves and entire warts of them upon the fand: nay, I likewife offered fome of them a mafs or lump, prepared of fome bruifed tubercles, in order to invite them to eat; but all was to no purpofe. I therefore finally enclofed fome of them in a dry box, into which I had before put fome rotten wood, that I might fee whether they would make their webs there. All thefe died likewife, pining away, fome fooner, fome later: wherefore I at length learned, that they could not live naked or uncovered in the air.

On the 5th of July I obferved, that fome of thefe little Worms had dug into the fand, and there began to weave webs; and this was the firft opportunity I had of difcovering any approach toward their change. For, when I diligently examined the fand on the infide, I found a great number of them in it, fome of which lay much deeper than others. And thus I at length difcovered, that thefe little creatures, after they have eaten fufficiently, quit the Willow-leaves, and fall; and then dig into the earth, in order to weave their webs there, and fuffer other changes.

Out of this fand likewife I took fome perfect webs. They were of an oval figure, Tab. XLIV. Fig. IV. *a*; fo that if they were expofed on the furface of the earth, the moifture or rain could not do them great harm. I have likewife obferved fome Spiders woven up in webs. Thefe webs were of a bright purple, approaching to fcarlet. I afterwards opened one of thefe webs, woven by the infects; but found that the Caterpillar, in the infide, was not yet changed. On the 6th of July I cut open fuch another web; and in this alfo there the infect ftill lived, in full vigour. In the third web which I opened, I found the creature juft on the point of fuffering its change.

Its green colour began by degrees to difappear. The body became a faint yellow, and decreafed decreaſed very much in bulk, becoming at the ſame time clear and perſpicuous; as is likewiſe the caſe in Silkworms. The little line on the back, produced by the contents of the ſtomach, became likewiſe obliterated by degrees; ſince the Worm had now cleared its inteſtines of all their groſs contents, afterwards lying in its web without any remarkable motion.

July 13, I found ſome dead in their webs; but others had by that time aſſumed the habit of real Nymphs. Therefore it is evident, that theſe inſects ſtrictly belong to the firſt mode of the third order of natural changes; though I ſhall not here refer them to it, becauſe they weave their webs, and are changed in a very obſcure manner under the earth.

Some days after, that is July 18, I obſerved many little black Flies iſſuing, Tab. XLIV. Fig. IV. *b*, out of thoſe webs which I had taken out of the ſand, and put into a dry box. This little Fly, being viewed with a microſcope, ſhews itſelf divided as uſual into a head, thorax, and belly. Out of the fore part of the head ariſe two black horns, Fig. V. *c*. Theſe are placed before the eyes. The thorax is elegantly divided, and ſhews four membranaceous wings fixed to its ſcapulæ, whereof the lower pair are covered by the upper, and all together cover the body. The upper wings are provided with many pulmonary tubes, paſſing through them, and near their extremities are marked *d d* with two blackiſh ſpots. Six legs adhere to the loweſt region of the thorax, *e e*, that are divided by joints and two claws: they are of a colour approaching to black. The abdomen alſo is black, and is divided into rings. Some of theſe Flies alſo had a tail, others not.

The males I found had tails, but the females none. If the laſt rings of the females abdomens were preſſed out, Fig. VI. *f f*, towards the hinder extremity, a ſharp-pointed part was forced from thence; which being carefully examined with a microſcope, exhibited an inſtrument like a ſaw, *g* ſituated *h h* between two pointed horny or bony little parts, and conſequently fit for piercing the coats of leaves; as I ſhall relate hereafter. On viewing the under part of the female's body, I obſerved that it grew white about the breaſt, but that the legs were ruddy there.

But when I afterwards opened the female's abdomen, I found perfect eggs there, exactly like thoſe, which I before deſcribed to be found in the tubercles of the leaves: ſo that doubtleſs, they are eggs of this Fly, which are found in the tubercles. This Fly is of the ſame diſpoſition with thoſe which proceed from conſumed Chryſallides. Nor did Flies break out of thoſe webs only, which I had put into the box: they likewiſe iſſued out of the webs, which were yet buried in the moiſt ſand. Hence I ſaw ſome ſuch little Flies lying dead in the ſand, and others that had grown faint and weak with the moiſture.

In ſome other webs I found living Flies which iſſued from thence ſo quickly, that I could not catch them. I likewiſe opened ſome males of this kind, and therein found the male organs of generation: however, I cannot now ſay much of them; becauſe I did not commit my obſervations thereon to writing. Theſe little inſects are changed in a double manner: for when it happens, that their Worms, at the end of the year, creep into the ground, and there form webs; Flies do not proceed from them before the ſpring of the following year.

I cut open alſo the webs that were forſaken by theſe Flies; which indeed, they break in a very ſingular manner: they make a round hole *i*, Tab. XLIV. Fig. IV. in each, like that in a barrel. In thoſe webs I found a ſkin, which the little creature caſt off, when it became a Nymph, and alſo a tender ſkin, which the Nymph, on being changed into a Fly, had afterwards caſt.

After the creatures forſake the tubercles; theſe latter grow dry entirely, and in ſome days become contracted together. But as my curioſity had proceeded ſo far as to keep all theſe little inſects, as they are circumſtanced in all their changes; hence I learned, that theſe tubercles could not be otherwiſe kept in the Willow leaves, than by filling them with a ſufficient quantity of dry ſand, and then leaving them to themſelves, until they grow dry: after this, the ſand may again be eaſily taken out of their cavity. Let this ſhort deſcription of this great and unheard-of natural miracle ſuffice; in which the wiſdom and providence of God are clearer than the meridian ſun.

In what manner the eggs of theſe little creatures come into the leaves of the Willow-tree.

MANY who call themſelves ſearchers into nature's ſecrets, agree, that all obſcurer modes of generation muſt be attributed to putrefaction as their cauſe, which is the effect of moiſture joined with heat. And this opinion extends even to ſtones; for they obſerve, that ſome inſects iſſue from them. It is however very remarkable, that they cannot prove or illuſtrate that aſſertion by any one ſolid argument, or fair experiment. They rely only on their own erroneous opinion, occaſioned by an univerſally prevailing error. I except only Dr. Francis Redi, who has pointed out a very different and much better way: for he, having firſt, by irrefragible arguments and reaſonings, deſtroyed the ſyſtem of generation by putrefaction; yet not improbably infers, that theſe little inſects, which are found in leaves, fruits, and the like ſubſtances, are generated there from the very ſoul and natural vigour of the vegetable which produces the fruits and plants. I ſay, the opinion of this gentleman is not altogether

together improbable; for the experiments that may be made concerning the matter, are involved in fo many difficulties, obfcured by fuch thick darknefs, and are fo inextricable, that one may be eafily induced to think thefe little creatures are really generated from the plants themfelves.

This induced me to inveftigate, with much labour and difficulty, the origin of the Worm in the tubercles of Willow-trees. Dr. Redi fays, he could never fee that the Worm itfelf is changed; and, I confefs, I fhould eafily have concurred in opinion with this gentleman, if I had not, though he did not fucceed, difcovered the abfolute change of this Worm into a Fly, and had not obferved the eggs in the Fly's body to be like thofe which are found in the tubercles. I cannot agree with this very learned author, that the Worm has only fix feet, as it is reprefented by him; for I find, on the contrary, that it is provided with twenty.

Thefe are errors into which each of us may eafily fall. And, indeed, I have not advanced what I have hitherto faid with defign to confute a gentleman who is my friend; for I think none ought to be cenfured with the rod of correction, but thofe petulant perfons, who, fwollen with vain-glory, bark like Dogs at all writings whatfoever, and feek laurels for themfelves by defaming others, which Bartholinus endeavours to do on every occafion; and hence even his thefes are debafed by railings. Indeed, all our writings out to be directed to find out the truth with our beft ftrength: I fay, the truth, to which we all ought to adhere, whether it favours or oppofes our own opinions, fince there is nothing really amiable but its beauty only. Therefore, though the opinion has an air of probability, I fhall not agree with the celebrated Redi, that any creatures are ever produced from vegetables, in the fame manner that leaves and fruits iffue therefrom.

I know indeed fome learned men, and fome of very eminent rank alfo have been brought into this opinion. But I know too, that it will never be proved by experiments, however fair it may appear. For I am really obliged to confefs, that opinion feems to be fo confonant to truth, that, unlefs thefe Worms had increafed into winged and ftinged animals before my face, I could fcarce have faid any thing to the contrary. Finally, in order to give my own opinion, with which I obferve the very excellent phyfician Dr. Francis Redi formerly concurred, I think, indeed, that all thofe tubercles of plants, leaves, fruits, and excrefcences in the which infects are found, are of no other ufe, nor do they grow for any other end or purpofe, but to give a fafe habitation to the animals in them, in order to preferve them, and likewife to ferve for food *. Indeed, extreme neceffity, in this cafe, required fuch provifion; for many of thefe Vermicles have no feet, by the help of which they might move about, and get food for themfelves. This is particularly remarkable with refpect to the Worms of Bees and Ants, which have no feet; fince the former are, for this reafon, very carefully nourifhed by the Bees themfelves; and the latter are, for that reafon, continually removed into different places, in which they can get food without affiftance. Tho' the Worms which we have above defcribed have feet, they make moft ufe of them when they feek for the habitation, wherein they weave their webs; but they by no means ferve them to find out their food. Therefore, both in the conftitution of the parts, and in the food, which the Worms found in the tubercles, there feem to appear reafons of great moment, why thefe tubercles are produced. Thefe are perhaps, however, mere conjectures; while Nature herfelf never intended, in her works, any thing to verify them. God fhews himfelf every where equally adorable and immenfe.

I think thefe Worms, which are found yearly within the fame kind of tubercles, and are peculiar and natural to them, are produced only from eggs of infects of the fame nature, or congenial with them; that is, fuch infects as depofit their eggs on the plants, leaves, or fruit, and convey them thither from without. This is indeed evident from what I have before obferved, with refpect to the eggs that lie in the tubercles of Willows, and thofe that are found in the bodies of Flies produced from thence: for thefe two kind of eggs do not in the leaft differ from each other.

Now, then nothing further remains but to explain the method whereby thefe eggs are conveyed into the leaves of the Willows. Nor do I fee much difficulty in this matter: for, fince the mother Fly is armed with one or two weapons, proper to pierce fuch fubftances, and with another inftrument, which is fitted for directing and guiding the eggs iffuing out of her body; fhe may very eafily pierce the tender leaves, when recently fpringing out, and may caft her fmall, and almoft invifible eggs, into the little holes that are thus made: that this really happens, and in this manner, is the more manifeft; becaufe, in the new leaves that have juft appeared, the little egg is found every where loofe and difengaged; and only a part of it is fituated between or under the coat of the leaf: nay, I have fometimes thought I faw the little holes, thro' which the eggs were conveyed into the fubftance of the leaf.

I own, this hiftory would at length be completely perfect, if I could fee all I have advanced, as my opinion, which, I think, I fhall hereafter be able to do. But though I have not hitherto done that, the experiments which I have now propofed, to confirm my opinion, feem to me fo ftrong, that no body can defire more convincing. I willingly confefs, I have not accurately and diftinctly feen the perforation of the leaf in all its circumftances: but I fhould think, that it is not poffible for it to come within the cognizance

* Reaumer, indefatigable in his fearches into the infect-world, has given us an account of a peculiar race of creatures, which he calls Mineurs des Feuilles, miners of leaves. Thefe burrow between the outer rind and fubftance of the leaf, feeding as they go, and leave a tract of white behind them, fo that the leaf feems variegated.

cognizance of the eye-fight. For, who can fee the wound in his fkin, made by the ftroke of a Gnat or Flea, immediately after it is inflicted? Surely no one. What one fees in the fkin, is nothing elfe but a change of colour: and this is likewife obferved in the leaf of Willows; that is, the place through which the egg is conveyed and joined to the leaf, is diftinguifhable in no other manner but by a fmall difcolouring. To which we may add, that the little wound, given to the fucculent leaf, by fo fmall a creature, eafily clofes up again, and is ftopped and filled up by the impelled humours.

It will be afked, why are tubercles produced in the Willow leaves, for the benefit of thofe eggs conveyed into them? And how are thofe rare and admirable excrefcences generated in other plants and trees? I confefs this queftion is very difficult to explain. Nor do I know what other anfwer to make to it, but that the firft ftroke, which the infect mother gave the plant, fruit or leaf, into which it endeavours to put the egg, is the real caufe of the tubercles produced afterwards, whatever form or figure it may affume. Do not we thus on Pompions, and other fruits, and even on trees, by the help of a knife, or bodkin, cut letters and characters; the veftiges whereof infenfibly fwelling with the humours, raife themfelves up confiderably beyond the common furface?

I do not think this is done by chance, but by a previous defign of nature, which has ordered, that this generation of infects, and the tubercles which ferve for nourifhing them, fhould be produced in this, and in no other order. Therefore alfo, the generation of thefe infects is plainly regular, and is not fubject to any fortuitous change. The great Harvey, in his book of generation, fully demonftrates, how much the ftrokes, ftruck with one and the fame external inftrument, differ from one another; when he fays, from experience, 'That the flefh itfelf diftinguifhes the 'poifoned ftroke of a fting, from that which is 'not poifoned:' and further proceeds: 'And 'therefore, from the poifoned wound, it is 'ftrained and condenfed, and therefrom arife 'tumours and inflammations. I once, fays he, 'for the fake of the experiment, pricked my 'hand with a needle, and immediately after, in 'another place, with the poifonous tooth of an 'African Spider; I could not difcover any dif'ference between thefe two little wounds in feel'ing; but there was a great difference fhewn in 'the fkin; for when the poifoned puncture had 'been made, it fuddenly fwelled.' Who can prefume to deny, that plants have this kind of fenfe? I fhould indeed think they would exhibit manifeft figns of fenfe, if they had mufcles; the want of which feems to be only the caufe, that prevents their being able to fhew us their faculty of fenfation. This is evident in the celebrated fenfitive plant; which, in my opinion, has a certain fpecies of mufcles, by the help of which, it extends and contracts its little boughs, almoft like arms.

As to the different figures of thefe tubercles, which are never found on plants, but they are pregnant with little infects, to be nourifhed within them; I think they are caufed principally by the variety of the ftroke, whereby thofe creatures perforate plants, and fix, and, as it were, inoculate their eggs in them: this may be likewife feen in all inoculations. For the fame reafon, the Flea forms with its ftroke in our fkin, a fwelling altogether different from that of the Bug: and the latter differs alfo from that of the Bee. All thefe things are far from being fubject to chance; they proceed in a certain order, and they are obferved to be always fimilar: except when the plants, or bodies of animals, have different figures; as the celebrated Redi hath accurately and clearly obferved in regard to the bites of ferpents.

I have often feen the legs of infects fo ftrongly impreffed upon the tender branches of trees, that they could not be taken off without injuring them. But, principally, the Dutch phalæna, which proceeds from the Worm, found chiefly in the bark of Willow-trees, and of the Maple, which it corrodes in fome meafure, and impreffes its eggs outwardly on the bark: hence it follows, that the Worms produced therefrom, afterwards make a paffage for themfelves inwardly towards the wood. Nay, if you pull thefe Worms out of the tree, they firft weave and cover themfelves with a web; and then having afterwards broken it, they pierce the wood with their teeth; and, in fo doing, reft upon the web on their backfide, in order to get fufficient power and ftrength to penetrate.

This winter, I obferved in turnips many warts and tubercles of various fizes, in which lay fo many Worms without feet, but furnifhed with eyes and hard teeth. In the fmalleft of the warts or tubercles, I found a little egg; and in the larger fort, a tender and foft Worm. In regard to thefe Worms without feet, that are found in tubercles on plants; it is worthy of notice, that they can by no means be kept alive, when they are drawn out of the cells, which they have formed for themfelves, in proportion to the bulk of their body within the excrefcences, and in which they are nourifhed. The cavity, wherein that wonderful Worm is lodged, which lives enclofed in the young buds of Willow trees, as in a rofe, which will be afterwards particularly defcribed, exactly anfwers to the bulk of its body. The Worm that lies in Turnips, has a cavity fomewhat larger than its body. I have obferved alfo, that thofe little cells, which the Worms, without feet, form themfelves with wonderful art in dry timber, are nicely fitted to their bodies; and they can therefore, with fufficient quicknefs, move through thefe cavities. They perform this motion by drawing in, and fixing their hinder parts to the wood, and ftretching out their forepart: and thus they move forward with great fwiftnefs in thefe burrows.

When thefe little infects are deprived of their cells or caverns, and the nourifhment they have there ready; they cannot move any more; they ftiffen with the heat and drynefs of the air, and perifh by innumerable other ways. Many feetlefs infects alfo, that live under the earth, and in the

the water, are nourifhed and fuftained in the fame manner. For thofe that have no feet, and live in the water, change place by the help of their tails and certain appendages, which ferve them inftead of oars. But the Worms that live under the earth, advance forward almoft in the fame manner as the Worms of Beetles, and creep in this manner between the cracks and fiffures of the mould. What happens to the feetlefs vermicles of Flies, Ants and Bees, may be feen in the hiftories I have already given of thefe infects. As to the Caterpillars, and other of the many-leged infects; the matter is clear, and without all difficulty. Nay, it is no way repugnant to my propofition, that fome infects are obferved to iffue, after fome years, out of rotten wood: for, we know, that thefe infects arife there alfo from Worms, and that thefe draw their origin from eggs; the females regularly betaking themfelves yearly to fuch wood, and cafting their eggs into it. It is often neceffary, that fuch Worms fhould receive increafe for fome years before they arrive at their time of change; as is manifeft in the Coffus, and in that Worm alfo, from which the Holland Cantharis, commonly called the Golden Beetle, is produced. The fame thing likewife holds in the Aquatic Worms, that live in the tubular cells, as I have already remarked in the hiftory of the Ephemerus.

We muft further obferve, that many creatures that are faid to want feet, are really provided therewith. Thus the Earth-worms indeed have many feet, but they are conftituted in another manner than feet commonly are. I have clearly feen the fame thing in ferpents: thefe I have indeed obferved, have five forts of feet. Some of them have a thorny or fpinous excrefcence in the middle of their body, with two heads, almoft like the military Caltrops, and contain in the middle a little bone, which is articulated in the os pubis, and covered with a fkin; by the help of this, they can move quickly over the rough furface of the earth; and in cracks of rocks, I have feen others again provided with two fuch machines for their greater fwiftnefs. Two feet of a certain third fpecies were prefented to me, which being compofed of diftinct articulated bones, likewife carry claws on their extremities, which may be drawn out of them, like the hollow claws of hogs feet. I myfelf have examined a fourth fpecies, which had four articulated, but very fmall feet; the foremoft of which confifted of three joints, and two toes; the tops of which were armed with claws: another fhorter joint alfo, or, as it were, fmall thumb, armed with a claw, projected alfo out of their infide. The hindfeet alfo were made in the fame manner, only that they had one toe more than the forefeet. Laftly, D. Frederick Ruyfch, profeffor of furgery in Amfterdam, made me a prefent of a fifth fpecies, furnifhed with very tender feet; each of which confift of three joints, but they are not diftinctly vifible; becaufe they are covered even to the extremities with the fcales: at the extremity of them, is feen only a fimple claw, without any divifion into toes. Therefore, that little ferpent feems capable of making ufe of thofe feet, only on certain conditions or occafions; fince, on account of their great tendernefs, they are not able to fupport the body, tho' they may often contribute to move it with the greater fpeed. Behold, how admirable God fhews himfelf in all his works! the fmalleft of which moft clearly expofe to view his Magnificence, Majefty, and infinite Wifdom.

Of other infects found in the tubercles of Willows; and how they come there.

IN the preceding pages I have obferved, that when I opened the tubercles of the Willow tree, I found various other infects befides the Caterpillars there mentioned; and this may impofe upon, or deceive, the unexperienced, who are accuftomed to make experiments only flightly: fince it may be poffible, that one animal fhould be taken for another, and wrong conclufions drawn from thence. For this reafon, I fhall now explain that matter more fully. I have before obferved, that in fome animals not yet perforated, I found fome other animals, from which the infect before defcribed hath been fuffocated and killed. But in order to make this underftood, we muft obferve, that the leaves of Willows are frequented by various fpecies of infects, which indeed lay their eggs either in or upon thefe leaves; and thefe eggs at length grow into vermicles, fome with, others without feet. The unperforated tubercle, whereof I now treat, contained two kinds of animals; the Caterpillar, which I have defcribed above, and a Worm without feet, both which lay together in the fame cavity. But as both were nourifhed with the fubftance of the tubercle, and both difcharged their excrements into it; it happened, that the Caterpillar was fuffocated, and fo deftroyed by its companion.

When I firft faw fome of thefe feetlefs Worms in the tubercle, I took them for the Caterpillars I defcribed before, thinking, that thofe fprung from their eggs without feet; and afterwards, when they grew fomewhat bigger, that their feet appeared. But at length I difcovered, by repeated obfervations, that thefe feetlefs Worms are of a different fpecies: though, notwithftanding I am very certain, that their eggs are thruft into the leaves of the Willow tree, in the fame manner as the Caterpillar; and that the Vermicle that is to fpring from thence, is there nourifhed, and undergoes a change. The feetlefs Worm here mentioned, had already grown a little more than the Caterpillar. It has a paler head, and difcharges a great deal of excrements: But becaufe, I never obferved a confiderable number of thefe Worms, in the warts or tubercles of Willow-leaves, which they only occafionally inhabit; therefore the opportunity of inveftigating their change to the Fly-ftate failed me. Perhaps I fhall hereafter take farther pains in this inquiry.

In another excrefcence, I found a third fpecies of Worms, which were likewife without feet, and were twice as little as the former. Their head was formed almoft in the fame manner: but it was thicker, where it is joined to the thorax. I obferved alfo, two black fpots in the head, which probably were the eyes: thefe Vermicles changed their fkin alfo, and crept pretty quick. Sometimes two of thefe are found in one tubercle; and they then live feparated by their excrements, as by a wall between them: this very thing I have likewife fometimes obferved, when their tubercles touched each other. Thefe Vermicles or Worms, likewife feem to undergo their changes within the excrefcences; but at this time, the excrefcence affumes a rufty colour all over it. I have not yet diftinctly feen their change; becaufe they are not found to be very common. It muft be good fortune, if any one fhould happen to difcover the order, in which the limbs and parts of thofe animals increafe. I made thefe obfervations on the 28th of June.

When thefe feetlefs Worms have undergone their tranfmutation, or the Caterpillars, which I have defcribed, have left their tubercles; fo that thefe are open and empty, then various other little Worms with feet, vifit and hide themfelves in them, or caft their eggs there, in order afterwards to nourifh their young in thofe cells. The fmaller Spiders alfo frequently betake themfelves to thefe warts on leaves, that they may lie in wait, and catch the leffer infects that pafs by, and when caught, feed on them. For the Willow-leaves feed an infinite number of very fmall infects; fo that a whole treatife might be wrote on the different fpecies of minute infects that are found about thefe trees.

Among other infects, I found on thefe leaves a very fmall Cicada; which, as to its changes, and its manner of living, is altogether like the larger Cicadæ of France and Italy. Very fmall Caterpillars are likewife found there, affixing an oblong and gold-coloured web to the leaves; out of which fome remarkable fpecies of fmall Flies are ufually afterwards produced. When thofe Flies iffue out of their little cafes, they likewife throw out of them an operculum or cover, which is exactly round, as I have related of the web of the Caterpillar, which I have defcribed before and delineated.

Among the little infects which come from without, into the tubercles, I have obferved a very fmall one, that was white, oblong, Tab. XLIV. VII. and has very great vital ftrength. It had two black eyes, fituated in the loweft region of its head towards the thorax. Out of the forepart of its head projected two antennæ. It had fix legs, over which were feen four wings, enclofed in little knots. The body appeared to be divided into rings. This little animal was changed afterwards in to a black oblong Fly, with wings as long as the body. But when this change happened, the infect was not at all deprived of its motion; therefore it belongs to the fecond order of changes. The reafon why I defcribe it under the fourth order, confifts in this, that its change is inwardly perfected in a concealed manner in the hollow tubercles of the Willows. It is fo fmall, that it can hardly be delineated in its natural fize. One muft therefore firft know thofe different modes of changes, and what infects vifit the excrefcences of the Willows, before one can, without error, make experiments on this matter.

A particular defcription of certain infects, which live between the firft and fecond coat of the Willow leaves, and are changed into Beetles.

BESIDES the tubercles hitherto delineated, which contain the Caterpillar before defcribed, there is likewife another fpecies, Tab. XLIV. Fig. VIII. of Worms without feet, obferved to lie between the outmoft and inmoft coat of the Willow leaves: thefe I fhall now defcribe, and delineate them magnified, but I fhall firft treat of the leaf itfelf. The Willow leaf, as I have obferved before, confifts of three coats; whereof the inmoft is the moft fucculent; and may therefore ferve many infects which eat the entire leaf for their proper food: but the Vermicles whereof I now treat, eat only the inmoft part of the leaf, leaving the inward and outward coat entirely untouched: they do not indeed devour the little nerves of the inward flefhy fubftance, but only the matter in their inteftines. Since thefe Worms therefore confumed only the middle of the Willow leaf, hence it is, that they are always found lying immediately under the inmoft coat of that leaf; for this they eat and confume by degrees on the infide, until they come to the external coat, which very ftrongly fupports the nervous filaments of the leaf. Thus at length it happens, that the infide of the Willow leaf is hollow underneath, and becomes feparated from the external: this is the reafon alfo, why the two coats of this leaf grow dry in that part, and affume a rufty colour: and this fhews plainly, that the little animal lies between thefe two coats.

I fometimes have found feventeen fuch Worms in one Willow leaf, which then indeed appeared to be divided into fo many rufty coloured fpots. In order to underftand thefe matters more clearly, I have judged it proper to reprefent two of thefe fpots in the natural fize; whereof the one is clofed, and the other open, Tab. XLIV. Fig. I. *zz*. In the open fpot, it may be obferved, that the inmoft coat of the leaf is entirely removed from the middle larger nerve. It likewife appears there, that the fmaller nerves of the one fide, are entirely naked, and the matter that had filled their interftices is confumed. In the oppofite fide, befides fome excrements, there is feen the naked head of the Worm, together with the body, tranfparent through the elevated coat.

That what has been hitherto faid, as well as the method whereby the Worms performs all thefe matters, may be more clearly comprehended; I fhall now delineate the infect itfelf mag-

magnified, and ſhall deſcribe its external parts. This Worm, or Vermicle, has no feet; but it conſiſts of fourteen annular inciſions, which conſtitute its head, breaſt, belly, and tail. In the forepart of the head are ſeen two teeth *a*. The thorax, in that here repreſented, was very much expanded in breadth *bb*, and ſhewed in its firſt ring two ſpots of a ruſty colour, approaching to brown. The head alſo appeared to be of the like colour, but ſomewhat paler: there were alſo, very many tranſparent pulmonary tubes ſeen in the breaſt. The reſt of the body was formed *cc* nearly like the thorax. Out of the ſides of each ring of the thorax and belly there ſprung hairs like flaxen threads. The laſt rings of the body alſo, were variegated with ſome black ſpots. This whole Worm was of a beautiful white colour, ſomewhat approaching to green. It moved a ſlow pace, going forward by the aſſiſtance of the rings of its body; which it ſometimes contracted, and again expanded: and this it did more readily, whilſt it lay between the coats of the leaf, than when drawn out of it. The exuviæ, or skin which it caſts, was left between the coats of the leaf; where likewiſe lay the excrements, which the Worm had even thruſt into the hollow interſtices of the little nerves.

I have not yet ſeen the egg of this Vermicle, though I have very diligently ſearched for it; but I had begun that obſervation on the 20th of Auguſt, when the Summer draws to an end. I afterwards obſerved, that the Vermicles were too far advanced for me to be able to find out their proper conſtruction and hiſtory. The inveſtigation of that matter muſt therefore be deferred to another opportunity. However, even at that late ſeaſon of the year, I found, in a Willow-leaf, a very ſmall kind of orbicular ſpot, which I have figured therein, near the former ſpots, Tab. XLIV. Fig. I. *zz*. I expected to have found an egg in this; but when I opened it, I found a very ſmall oblong, black Nymph; which, I found on examining it with a microſcope, would at length change into a ſmall Beetle. But I could not then diſcover either the worm or the egg of this Nymph. When I attempted, and was deſirous to keep the Nymph, it was loſt from my ſight, on account of its extreme ſmallneſs. Conſider, reader, therefore, how minute that egg muſt be; the Nymph of which was almoſt inviſible. I began this obſervation on the 30th of Auguſt.

It is evident from what I have ſaid of the teeth of theſe Worms, with what inſtruments they gnaw and break open the inmoſt coat of the leaf. For the Worm, in a very irregular manner, hollows the leaf, forming a ſinus which runs into various angulated and ſerrated borders; by which means it widens its habitation by degrees, eating the ſubſtance of the leaf ſometimes round it, ſometimes lengthways, and at other times through the angulated curvatures. It is very admirable, that the Worm never eats even the ſmalleſt hole in the coats of the leaf. It ſeparates the internal from the external coat ſo carefully, and without injury, that the method whereby it is done would indeed be incomprehenſible; unleſs we conſider its fine teeth, by the help of which it conſumes the middle ſubſtance of the leaf. Hence it is likewiſe evident, that the orifice muſt be very ſmall, by which the egg of this Worm is firſt conveyed through the inward coat into the ſubſtance of the leaf, that it may live, be nouriſhed, and perform its metamorphoſis there.

On the 24th of Auguſt, I ſaw *a* Fig. x. one of theſe Vermicles put on the form of a Nymph in my chamber. This may be ſeen very exactly, by holding the leaf to the light of the ſun or candle. I obſerve, that this Nymph properly belongs to the firſt mode of the third order; ſince it very clearly, and without impediment, exhibit its limbs to view. In the beginning of this change, the Nymph is white; but it afterwards becomes gray, and by degrees black. It very ſtrongly moves its tail; by the help of which it can go between the coats of the leaf. On Auguſt the 26th, it became as black as pitch.

The head, thorax, abdomen, and all the other limbs of the future Beetle were now ſeen in it. In the forepart of the head were ſituated two crooked, Tab. XLIV. *a* briſtly hairs. In the lower part of the head, its mouth or trunk lay hidden in an oblong caſe. On each ſide, near the head, appeared the horns *bb*, elegantly compoſed, as it were, of little joints or knots. Near theſe was ſeen the firſt pair of legs; and under the latter another pair, out of which projected *cc* two briſtly hairs like two crooked prickles. Below theſe legs appeared the ſheaths or caſes of the wings; which proceeding from the back and bending, lay along upon the belly, and were beautifully divided with ribs *dd*. Underneath them lay the membranous wings themſelves, encloſed in a membrane; immediately under the caſes, the bending of the third pair of legs ſhewed itſelf: and this pair alſo was armed *ee* with rigid briſtly hairs. Next followed the rings of the body, and ſome prickles *f* projecting out of the tail; by the help of theſe the Beetle probably pierces the leaves. But this is merely conjectural; nor have I obſerved it, being then engaged in other buſineſs.

On the 30th of Auguſt, one of theſe Nymphs was changed into a Beetle, Fig. XII. after it had ſome days worn the appearance of a beautiful Nymph. When at the ſame time, I opened ſome other ſpots of the Willow-leaves; a great number of Nymphs preſented themſelves on the inſide; which when, after caſting their ſkin, they were changed into Beetles, I obſerved, eat thro' the leaves, and made very conſpicuous holes.

I have been informed by many travellers, that in hot climates, Worms are found in leaves an inch long: on theſe many fine experiments might have been made, if the inhabitants of thoſe places had not laboured under the curſed thirſt of gold, and prematurely broken the thread of life with intemperance. This Beetle is divided into a very beautiful head, thorax and tail. The eyes are very black, of a reticulated conſtruction, Tab. XLIV. Fig. XIII. *a*, and ſituated in the head at a very little diſtance from one another: under the eyes is ſeen a black, crooked ſnout, full of little cavities, and of a ſubſtance between bone and horn *b*, and on the forepart of the ſnout are placed the teeth of this Beetle. The little horns are very diſcernible, and are of the ſame colour with the ſkin of people who have been much expoſed to the ſun: they ariſe very gracefully from about the middle of the ſnout *cc*. They are each compoſed of eight joints, and are ſo thick at their ends, that they may very properly be called præpilata, or knobbed horns. The thorax conſiſts of a very black horny bone, and is full of white hairs, and little cavities; from the lower part of it ariſe ſix legs *ddd*; they are of a moderate thickneſs, but ſlenderer at their extremities. Theſe legs are covered with hairs, and with little irregular eminencies; in colour they reſemble the horns. Each leg conſiſts of ſix joints, and each foot of four, of which the laſt are armed with two nails. The ſecond joints of the two hinder feet are ſomewhat blackiſh, and much thicker in proportion, than the ſame joints in the fore legs.

The reaſon of this difference ſeems to be, that the former contain ſome very ſtrong muſcles, by means of which this inſect can ſpring on its hinder feet in the ſame manner as Flies, but ſomewhat ſlower. I ſaw one of them make a leap of three inches and a half, which is about twenty-eight times the length of the creature's body. The caſes of the wings are likewiſe black *ee*, but covered with a fine white down, and are ſurrounded with a ſmall border; they are alſo ribbed, and full of cavities; notwithſtanding which, they ſhine like the beſt poliſhed looking-glaſs. The wings are membranaceous, and twice as long as the caſes, ſo that to defend them, they muſt be folded up, which they accordingly do in a moſt exquiſite contrivance. Tho' I could eaſily procure inſects enough of this kind, I could not find time to diſſect them; for which reaſon I have nothing to ſay of their eggs, or of their genital, and other internal parts.

An account of ſome ſmall Worms that are bred within the new and tender leaves of Willows, and afterwards change to Flies.

ON the twenty-eighth of June I obſerved, in looking over ſome Willows, that ſome of their young leaves, which had but juſt made their appearance about the tops of the branches, began already to dry up and wither, Tab. XLIV. Fig. XIV. *a*. This was enough to engage my curioſity; and accordingly, I immediately ſet myſelf to diſcover the reaſon of ſo ſudden a decay. On ſeparating theſe withered leaves from one another, I found between them many collections of living Worms, to the number of eighteen or twenty together *b*, and as it were, in the moſt friendly and ſociable manner. Theſe inſects were of an oblong figure, but ſomewhat broader in the middle than at the extremities, and of a moſt delightful bright orange or ſaffron colour. Some of them had already begun to make their webs, and others were employed in preparing themſelves for it.

On this diſcovery I ſearched ſome other new leaves, and found in them a great variety of Worms of the ſame ſpecies, ſome more grown than others. I found alſo in ſome of the leaves the eggs from which theſe Worms had been hatched; but they were lodged only between the folds of the leaves, and not within their ſubſtance, as was the caſe in the laſt obſervation.

Theſe Worms lived merely upon the juices flowing from the leaves where I found them; but as this juice is very tough or viſcous, it may naturally contain ſufficient nouriſhment for them, and ſo render unneceſſary their preying on the ſubſtance of the leaf itſelf. Whether this juice flowed ſpontaneouſly from the leaves, or whether they made inciſions in them to extract it, is a thing which I cannot take upon me to determine. I never ſaw any of theſe Worms ſtir from under the folds, and wrinkles of the leaves, but obſerved, that they conſtantly crawled under cover, from one cavity to another, till they had attained their full growth, and the embryo limbs contained under their ſkins, were arrived, by the due degrees, at a proper ſize, to prepare for their ſucceeding appearance.

When the leaves, whoſe greenneſs and growth is deſtroyed by theſe Worms, begin to harden and dry up, the Worms, without ſtirring from under cover, form themſelves webs, in which they at length become Nymphs. They make their webs ſtronger and thicker about the head and thorax, than elſewhere, as theſe parts are to be the chief ſcene of the enſuing changes, and of the growth of new limbs; and therefore require an extraordinary bulwark to defend them, eſpecially as the leaves about this time grow very hard and rugged, and therefore more apt to cruſh, and otherwiſe hurt the encloſed inſects. As theſe communities of Worms live under one cover, and in a kind of brotherly ſtate, on the ſame ſpot, they form their webs one cloſe to another, without any diſturbance and encroachment one on another.

The Nymph of this Worm is very ſmall, but it exhibits, notwithſtanding in its parts, the figure of the future Fly. It loſes all manner of ſenſible motion, except in the tail, which it is ſtill able to ſtir with great violence. On the fourth of July, I obſerved that theſe inſects were turned to Flies, which appeared through the microſcope, of a moſt delicate conſtruction, Tab. XLIV. Fig. XV. The head reſembling that of a pin, was joined to the thorax by a very fine and flender neck. On the forepart of the head, were placed two oblong horns. It had fix long black legs, and wings longer than the body, which glittered like mother of pearl. The body fcarce differed in colour from that of the Worm. This Fly, when moving through the air, appears no bigger than an atom of duft. It is very furprifing how ingenuous thefe little animals are in depofiting their eggs within the tender buds of fuch leaves as are fit to afford fhelter and nourifhment to the Worms that are to rife from them, that, by this means, they may be able, in obedience to the immutable laws of nature, to renew their fpecies from year to year, and continue it even to the end of the world.

Of Worms which are found enclofed in tubercles like Rofes, that appear on the tops of Willow branches; and likewife in many of the dwarf Willows that grow upon heaths and commons.

WE not unfrequently fee a tubercle formed at the ends of Willow branches, in the fhape of a Rofe *, and which the learned Mouffet accordingly calls by that name, Fig. XVI. *a.* In fome feafons, thefe tubercles appear in great numbers, and in others, they are fcarce. I once obferved, in company with Meffieurs Thevenot and Henon, that there was hardly a fingle Willow branch in all the open country, that lies near a little fea-town called Egmont, which had not one of thefe tubercles at its extremity.

After breaking off the external leaves of this tubercle, there appears in the middle an affemblage of other tender leaves, in form of a pear, Fig. XVI. *b*; which lie one over another, in the fame manner with the innermoft leaves of the Cinara or Artichoke, fo as to make it neceffary to pull them off one by one, Fig. XVII. *c.* in order to obtain a fight of the Worm, *d*, which lies hid within them, wrapped up in a tender and delicate membrane, or kind of web, *e.* This Worm lies there in an inverted pofture, with its head the loweft, and its tail the higheft part of its body; and it is fo narrowly confined within its web, and in the furrounding leaves, that it feems very probable, it cannot either move at all, or, at moft, not without great difficulty: in this refpect, it differs extremely from all the other Worms that have been before defcribed. On extracting it from the place of its birth, *f*, its body appears compofed of various rings, and is fomewhat flenderer towards the tail, than the head. Its colour is of a florid red, and by no means unhandfome.

The food of this Worm is no other than the juices of the Willow, flowing to the extremities of the branches, where the infect is moft conveniently placed to receive them. There is not the leaft excrement to be found with this Worm, nor indeed with thofe laft defcribed, which makes it probable, that, like the fœtus, while it lives in the mother's womb, and is there fubfifted by nourifhment, taken in after a peculiar manner, thefe infects retain their excrements till they appear in the Fly-ftate. I omitted unfortunately diffecting this infect, though, by doing fo, I might have attained perhaps a fatisfactory folution of this uncommon circumftance. I could not have found any difficulty in inveftigating the matter that way, as I could eafily have procured what number of thefe infects I pleafed: but our negligence and inattention are fo great, that we generally defpife thofe things that are under our hands, to fatisfy an inordinate curiofity of knowing and poffeffing thofe which lie at a greater diftance, and are hard to be obtained. The beft of us muft own himfelf fo far the flave of vanity, as to be more defirous of producing any thing foreign and unheard of, than that which is fpontaneous in our own country. Though the Majefty and Wifdom of God, the fountain of all revealed wonders, moft evidently fhew themfelves the objects of our love, praife, and adoration, equally in every creature.

A fault of the fame inexcufable kind, made me forget myfelf fo far, as to neglect examining the egg of this infect, though the little rofe, which had firft engaged my attention, is produced merely to cherifh it. This is plain from the Willow branches never bearing any fuch excrefcences, unlefs thefe Worms are in them; for, when the parent infects happen not to depofit their eggs at the extremities of the branches, they fhoot into feparate leaves of the common form. Thefe Worms perform their changes for the Fly-ftate at two different periods, namely about mid-fummer, and in fpring, when the Willows begin to bud. Thofe which affume the Nymph-ftate, Tab. XLIV. Fig. XVII. *g*, in fummer, without ftirring from the place of their birth, in a few days after become Flies, *h.* But fuch as happen not to be changed to Nymphs till autumn, continue enclofed in their covertures till the enfuing fpring; when, on the fun's nearer approach, they likewife become Flies: all thefe Flies immediately betake themfelves to the Willows, where they may be fure their offspring will find convenient food and lodging.

The Fly is of a middle fize, but of a very delicate conftruction. The extremity of its body is armed with an aculeus or fharp weapon, by means of which, it may open a paffage for its eggs into the tender tops of the Willow branches. It has two horns on the forepart of its head, two membranaceous and confiderably long wings, and fix long flender legs, formed very like thofe of the common Gnat. As to its colour, I forgot to obferve it particularly. Thofe Flies which I

* This peculiar excrefcence of the Willow, we have very common in the fenny counties in England. I have feen them on the edge of Lincolnfhire, as large as a common red rofe, and very double. In this ftate they make a very beautiful, as well as peculiar, appearance: and our old Englifh botanifts, who were not acquainted with this part of natural hiftory, fuppofed the tree a diftinct fpecies, and called it Salix Rofea, the Rofe-Willow.

dried,

dried, in order to keep by me, are of a dark gray. I have fometimes obferved four Flies to proceed from one of thofe Willow rofes, but they were four times lefs than thofe kinds, which require each a whole rofe to itfelf. Thefe fmaller Flies were of a refplendent jetty black colour, had fix legs, and fhorter horns than the other kind. Their two wings were adorned with a black fpot, each in the middle of its extremity: fome of them alfo were provided with a fharp aculeus or weapon at the tail *.

At prefent I can fay no more of thefe Flies, being fo much taken up with other bufinefs at the time of my writing thefe obfervations, that I have not leifure duly to revife them. I muft therefore refer this tafk to another opportunity, if it fhould pleafe God, the difpofer of all things, to offer me the means of performing it.

Of certain Worms without feet, found in the Hazel-nut.

THESE Worms are fo common, and fo eafily to be had, that a defcription of them may feem in fome degrees fuperfluous. Their bodies are white, foft and hairy, their heads are red, and armed with two fharp teeth, with which, in autumn, they bore themfelves a paffage through thofe nuts in which they had hitherto refided; but which they then forfake. Thefe Worms may be found fometimes lying in hundreds together, at the bottom of drawers and bafkets, in which hazel nuts have been kept. I have often formed a refolution of examining accurately the nature and difpofitions of thefe Worms, but have not as yet an opportunity of doing fo. Neverthelefs, I fee no reafon to doubt, but that they, as well as all other animals, derive their origin from an egg, thruft from abroad into the fubftance of the young nut, or perhaps into the bud or flower, out of which it is to be formed, as has been already obferved, of many other little animals of this kind.

There is no keeping thefe Worms in dry boxes; for they will live in this confinement but a few weeks. But in pretty moift fand, fome of them have furvived with me the rigour of a whole winter, and lived to the 24th of March; and all that time without any food. Some of them, after undergoing this fevere treatment, were yet vigorous enough to fet about their mutations: but, by digging continually into the fand, in order to fatisfy my curiofity, in feeing what they were doing, I wounded fo many of them, that as yet I have not been able to difcover what kind of creature they finally become.

I obferved befides, that fome of them burrowed much deeper into the fand than others; and I even found fome at three inches under the furface. I never could perceive any web about them, nor do I believe that they form any, as they always appeared lying in the fand entirely naked. Neverthelefs, I do not think there is any reafon to doubt, but when thefe Worms efcape from the nuts, and leave the hazel fhrub to live in or under the ground; they, in this laft fituation, change to Nymphs, and afterwards, in the enfuing fpring, to a kind of Flies, which again depofit in the tender rudiments of young nuts, eggs, like thofe from which themfelves originally were produced. It would be no difficult matter to afcertain, by experiment, the truth of this conjecture.

Of Worms found between the two coats of the Alder-leaf.

FIRST OBSERVATION.

ON examining fome Alder-leaves on the 20th of Auguft, I obferved the fubftance lying under the furface, formed by the internal coat of the leaf, was in many of them irregularly gnawed away in little angular cavities, without any paffage to the outfide of the leaf, that I could difcover; nor had the leaves, in which thefe cavities appeared, loft any thing of their greennefs or frefh hue, as the Willow-leaf juft fpoke of had done. The internal coat, hollowed in this manner, rofe confiderably above each hollow, into a kind of little canopy, Tab. XLIV. Fig. XVIII. *a*, whereas, on the oppofite parts, the other fide of the leaf, which is covered by the external coat, was only a little altered by a few fmall wrinkles, *b b*; this no doubt was the true caufe of the extraordinary roundnefs and convexity of the oppofite tumor.

On opening one of thefe fwellings, I difcovered between the two coats of the leaf now fpoken of, a perfect web, formed exactly like that of the Moth in its Worm-ftate; and, on opening this web, I difcovered a Chryfalis, *c*, in point of fhape and conftruction, plainly belonging to the fecond mode of the third order of changes. The fkins under which this infect had lived in the Worm-ftate, lay near it under the fame web. I could alfo difcern that it was, by means of this web, the Worm had reduced the furface of its cavity, formed by the external leaf, to the appearance already defcribed. On each fide of the web lay the Worm's excrements. The method ufed by this Worm, to form itfelf, between the two coats of a leaf, a cavern or neft in which it may conveniently perform its mutations, is certainly one of the moft furprifing objects that natural hiftory offers to our confideration.

As to the Worms themfelves, I could not difcover any of them, or any of the eggs, out of which they muft have been hatched. In all the leaves I examined for this purpofe, there appeared nothing, only webs; fo that the feafon, for finding eggs or Worms was certainly elapfed, at the time when I looked for them. The Chry-

* The females have all of them this weapon at their tail; the males never. The reafon is very plain, for its ufe is to bore a hole in which to lodge the eggs; therefore only the female has occafion for it. This author has obferved the fame on other occafions, in various fpecies of Flies.

falis,

fafis, viewed through a microfcope, plainly exhibited the form of the Butterfly, to which it was thereafter to be changed. It was oblong, fomewhat flatted and broad on the fore part, where it terminated in a point, Tab. XLIV. Fig. XIX. *a*, whilft its hinder part grew gradually narrower, fo as to refemble a pyramid or cone, *b*. Each fide of the body was covered with a few, very delicate hairs, *c c*. Its furface was of a pale brown colour. The eyes appeared on the head, *d d*, and under them a double trunk *e*. A little lower down, and juft by this, the firft and fecond pairs of legs were feen, *f f*. The antennæ or horns, which were of an extraordinary length, extended from the eyes to the very extremities of the two firft pairs of legs, *g g g g*. Near thefe lay the wings, *h h*. The hinder pair of legs was placed between the antennæ, and ftretched beyond the extremities of thefe parts, *i*. The body confifted of feveral rings, *k k*. This Chryfalis looked as if it had caft its fkin but a few days, and it moved its tail very vigoroufly, making ufe of it to turn itfelf, and indeed to move from one place to another.

On the 26th of Auguft, two of thefe Aureliæ yielded two very elegant Butterflies, lefs than Moths of cloaths; but like them in colouring and ornaments, as may be feen by the drawing I have given of them, where they are reprefented of their natural fize, Fig. XX. It is hardly poffible to conceive a more beautiful little animal, than what this Butterfly appeared to be, when viewed with a microfcope, Fig. XXI. It confifted of a head, thorax, and abdomen. The head was furnifhed with two antennæ or horns, *a a*, and a fhort and crooked double probofcis or trunk, *b*. From the fhoulder blades of the thorax fpring four wings, and from the under part fix legs. The wings were partly of a mere membranaceous fubftance, and partly compofed of delicate feathers, or fcaly hairs. The upper pair fhone and glittered moft glorioufly with crefcents of gold, filver, and brown, *c c*, furrounded by borders of a delicate black: befides this, they had a black fpot at the extremity of each. Moreover, thefe extremities were edged with little feathers, which made them look like a creft, when they lay clofe upon the body, one folded over the other. The lower wings are likewife in a great meafure covered with feathers, *d d*, and are of a pale colour, and filvery brightnefs. Along the middle of the wings there runs a membranaceous little ftem, from which iffue the feathers that, in a manner, compofe them; and even this ftem has, as it were, its own fcaly feathers to defend and adorn it.

All the ornaments beftowed with fuch profufion on the wings of this little infect, confift in reality of feathered fcales of different lengths, and various diverfified colours; and they are divided, more or lefs, into lateral branches, like the feathers of the larger winged animals. The colours are more lively or faint, according as the fcales forming them lie together in greater or fmaller quantities; and from the fame conftruction, and contrivance alone, refults all that ftriking variety in the wings of Butterflies: for, on rubbing of their feathers, they appear entirely even and plain, like the furfaces of all other membranes.

The legs of this Butterfly are entirely covered with the fame kind of plumage, and they are divided into joints: every extreme or loweft joint is armed with two little claws. The hinder legs have, befides thefe, three little white prickles, or fpurs, Tab. XLIV. Fig. XXI. *e e*. The body is divided into rings, and covered likewife with feathered fcales of a bright filver whitenefs. This little animal, being put in a box that had ferved to keep Brazil-fnuff, began immediately to tremble, and in lefs than two minutes expired in a convulfion that feized every limb. As yet I have made no more obfervations of this infect. The furprifing manner wherein the Worm, from which it is produced, neftles and feeds between the coats of the Alder-leaf, will, I hope, alone be judged fufficient to recommend to the curious what I have faid upon this occafion.

SECOND OBSERVATION.

THE 30th day of Auguft I found, between the fame coats of Alder-leaves, a flattifh Worm, of the fize and form reprefented at the letter *d*, Fig. XVIII. as it appeared on removing from it a part of the coat belonging to the leaf on which it had fed. The body was oblong, and fomewhat broader about the thorax than at the belly or tail. The head was large, of a pale brown colour, fomewhat flattifh or depreffed; and on its fore part furnifhed with two eyes, and a pair of fharp teeth. From each fide of the lower part of the thorax there arofe three legs. In the tranfparent body there appeared a little green ftreak, produced by the Worm's food. Counting the head and tail, this Worm confifted of twelve rings.

I difcovered alfo, that this infect had caft a fkin, in the fame place where I found it. The internal fubftance of the leaves, where it refides, ferves it for food; and it had accordingly gnawed this fubftance away, without offering to touch the adjacent coats, into a great many windings and turnings. As this parenchyma, or pulpy matter, had been but lately devoured, the leaf, even in the fpot where the devaftation had been made, ftill retained its verdure; but foon after it withered, and changed to the colour of the leaves of the Alder that fall in Autumn. The external coat of the leaf, in which the ribs appeared, was very ftrong and thick; but the other fide, or internal coat, was very thin and delicate. The excrements, which were at firft green, and then grew black, rolled freely backwards and forwards within thefe two coats. I could not difcover in thefe leaves the fmalleft opening, by which the enclofed

Worm

Worm might be fuppofed to have infinuated itfelf into their fubftance. Some of the Worms within thefe coats were dead, which I attributed to the ftriking of the leaves againft one another with the wind; or to their withering and wrinkling up, for want of nourifhment; or, finally, on account of other external injuries. As yet I have had no opportunity of tracing this infect through its changes, fo that I have nothing more to fay here concerning it; but that it was very delicate, and moved itfelf but weakly. On taking it from within the leaves, it died in a day or two. The Alder is not the only tree inhabited by thefe Worms: they are to be found alfo on the Pear and Apple, and many other kinds.

THIRD OBSERVATION.

ON the 31ft of Auguft I found, within the fame coats of certain Alder-leaves, a third fpecies of Worms which had no feet, and were divided into twelve rings. This fpecies had a much rounder body, Tab. XLIV. Fig. XVIII. *e*, than the firft, with a very fmall head and teeth. The back and belly were diverfified with various white fpots, which appeared through a yellowifh green tranfparent fubftance, and feemed to me to be fo many particles of fat. The neft which this Worm had gnawed itfelf within the coats of the leaf, was not fo fpacious as thofe of the two Worms laft treated of; and fometimes one neft contained two Worms, which lived and fed together in common; but in this cafe, the neft was fomewhat larger. In another leaf I found two of thefe Worms, that had each formed itfelf an oblong web, *f*. In the fame place I alfo found their excrements, and the fkins they had caft off.

Thefe webs were red, as were alfo the fhrivelled coats of the leaf that contained them. On opening one of thefe webs, in hopes of finding a Nymph, I met with a Worm, which as yet had fuffered no change, except that of being grown a great deal fmaller than before; and it was impoffible it fhould not have loft fomewhat of its bulk, confidering the great quantity of filk it had drawn from its body, to form itfelf a covering. Four weeks after this, I opened another web, little thinking that I fhould meet with a fecond difappointment, yet fo it happened; for there was no Nymph even yet, but only the Worm lay there quite unaltered. I have therefore laid by fome of thefe webs, in order to difcover next year, if poffible, what kind of an infect they produce, which is poffeffed of the furprifing art or power, as a faculty of burying its eggs thus fubtilely within the two coats of leaves. When thefe Worms are very fmall, their nefts, which they gnaw themfelves, are very fmall likewife, Tab. XLIV. Fig. XVIII. *g*; but they widen proportionably by degrees, *h i*, as their inhabitants grow bigger and bigger. From whence I conclude, that the holes in which they have been originally depofited, in form of eggs, muft have been of a minutenefs almoft beyond conception. But, as yet, I have no experiments or obfervations to enable me to fay any thing certain on this head.

The fame fubject continued. Hiftories of infects that are found in fruits, tubercles or warts, and leaves of plants. An obfervation on the common Thiftle growing in the fields of Holland.

WAlking about the middle of fummer into the country, in order to find leaves for Caterpillars I was at that time feeding, I happened to obferve on a common Thiftle, not as yet arrived at its full growth, a yellowifh flender Fly, Tab. XLV. Fig. I. *a*, with a large head, red eyes, two fhort antennæ, and wings very elegantly coloured. This infect had thruft out, to a very great length, the extremity of its uterus or womb; and was employed in endeavouring to bore, by means of this part, a hole into the fubftance of the leaves, wherein it might depofit its eggs. This curious fight could not fail of engaging my attention, and accordingly I fpent a long time in viewing it, equally aftonifhed at its novelty, and overjoyed at having an opportunity of feeing, with my own eyes, the manner in which this kind of infects attack the plants, which are proper to afford their Worm-offspring a never-failing food and fhelter: as likewife to obferve their method of conveying into thefe plants the eggs from which their Worms are to proceed. In that part of the plant where thefe eggs have been depofited, there afterwards grows a large globus, or round tumour, in fubftance not unlike the calix or cup of the Hazel-nut, which by degrees becomes ligneous, and hardens to a more compact fubftance, refembling wood. Within thefe fwellings there appear, here and there, certain white Worms, which change firft to Nymphs, and then to Flies. Some pretend this Worm, carried in a purfe, along with its tubercle or fwelling, is good againft the piles.

Of Worms found within the tubercles or swellings of the stinging Nettle.

IT is very remarkable, that even in some stinging Nettles we meet with Worms, which are destitute of feet, and derive their origin from a very small but yet discernible egg. These excrescences are found on the Nettle, in a great variety of forms. Some are produced upon the stalk, Tab. XLV. Fig. II. *a*; others on the ribs of leaves, or the tender buds, *b*: some again lie confusedly, here and there, all over the surface of the leaves, *c*. The substance, of which these swellings are formed, is very hard and compact, which makes it an easy matter to crack them. In colour they are somewhat of a yellowish green. On the 28th of June I found a great many, both eggs and worms, in these swellings. The smallest of them contained each one egg; those somewhat larger, a worm; and the largest of all, which were composed of two or three of these swellings growing together, afforded shelter to two, three, or even four Worms of different sizes, and all this at one time.

The largest of the Worms I discovered at this period, were exactly of the same size with that, whose form, taken from the life, I exhibit in this figure, Fig. III. *d*. This Worm, viewed with a microscope, appeared somewhat broad, and depressed in the middle, *e*, and armed on its forepart with a delicate slender snout, *f*; its body was almost white, but a yellow streak appeared within it, which the Worm's transparency rendered very discernible. I found afterwards that this was an intestine, and that the colour of it was entirely owing to its contents. The skin of these Worms had some delicate hairs scattered loosely here and there over its surface, *g*.

On opening some more of the swellings on this plant on the third of July, I found some of the enclosed insects were changed into Nymphs. Such of them as had lately cast their skins were white, but the older Nymphs exhibited a variety of colours. These Nymphs belong to the first mode of the third order; for it was easy to discover in their limbs the form of the future Fly. They very plainly appeared to consist of a head, thorax, and belly. In the head, I could discern two remarkable eyes, Fig. IV. *h*, of a reticular form, which were beginning to look red; and on the sides of the head the horns, legs, and wings, were curiously folded up, and might be seen springing from the thorax. The rings of the body were very conspicuous, and it had a little tail bent back, so as to lie over them in a very elegant manner, *i*. All these parts, the legs and wings excepted, were changed by degrees from white to yellow, which they afterwards lost, to assume a deep brown colour, and finally a perfect black.

On the ninth of July, many of these tubercles were burst open; and they no longer contained any insects, but only some of the cast-off skins. This gave me room to judge, that the Nymphs I had observed on the third of this month, had passed in the interval from that time, into the Fly-state, and my conjecture was confirmed by what happened in the tubercles I kept at home in boxes. To me it appears probable, that all these tubercles open of themselves *, at the time when the enclosed insect has its wings, and is in readiness to launch out into the air; and this may serve to account for my finding Nymphs at this very time, in some other tubercles which remained unopened, which had not as yet acquired their proper colouring, nor strength enough to cast their skins.

The Fly thus produced *k*, is furnished on the forepart of its head, with two longish black horns. The head is of a dusky brown, with a fine tinge of blueish green: and the eyes are red: from the upper part of the thorax arise four membranaceous wings, and from the lower six legs of a colour between red and white. In the males the body ends in a little tail, divided into two stiff hairs, or in a forked manner; so that this Fly is to be referred to the order that takes its name from this circumstance, Bisetæ; but in the females, this part terminates in a pointed weapon. The breast and body of these Flies is of a very delicate and resplendent green, like that of Spanish Flies, or Cantharides, so as to afford, when viewed with the microscope, a most entertaining and elegant spectacle. I unfortunately omitted dissecting these insects. To preserve these Flies and their Nymphs, I extend their limbs on white paper, and there fasten them down with a little moist starch, for they are too delicate to be fixed upon pins.

* So far as I have observed in these cases, the Fly, when perfect, gets out of the tubercle two ways, but both are by violence, not by the natural opening of the tubercle. Sometimes the substance is so hard, that the Fly is forced with great labour, to gnaw its way out: in other instances, the covering is by this time become nothing more than a thin, dry, and brittle membrane; and the successive swellings of the Fly's head, which have been mentioned on a former occasion, burst the rind and let it out.

Of the Worms that are found in some downy excrescencies of Oak-trees.

THE Oak-tree affords ſhelter and nouriſhment to as great a variety of inſects as the Willow; of this, at preſent, I ſhall produce only two inſtances. The firſt I take from the inſects which breed within a kind of downy or ſoft excreſcence at the extremities of the branches; the ſecond from certain other kinds which we find encloſed in a moſt remarkable and ſurpriſing manner, within the tubercles ariſing on the leaves. This woolly or downy excreſence, of which I now intend to ſpeak, is found in the form of a ball, Tab. XLV. Fig. VI. *aaa*, and is made up of a ſoft thready matter, like wool or cotton: it is compoſed of very delicate hairs, running in every direction ſo as to form a very firm and ſubſtantial web; but the hairs are not very ſtrong in themſelves, for they are hollow, and look as if they conſiſted of ſmall globules. They ariſe from the footſtalk, or from tops of the Oak branches *b*, and ſometimes from the leaf, which in many inſtances ſhoots, as it were, from the central part of the excreſcence *c*, ſo as to appear entirely ſurrounded with this down. But the principal foundation of theſe hairs is no other than ſome little oblong hollow bags or tubes, Fig. VII. *d*, if I may give them that name, which are at firſt ſoft and tender like purſes, but afterwards harden to the firmneſs, as it were, of wooden pipes.

Each of theſe cavities is conſtantly found to contain one Worm, which lies hid, and grows in them, till it changes in the Summer months to a Nymph, properly belonging to the firſt mode of our third order. Nevertheleſs, as I have already often hinted, I rank theſe inſects in the fourth order, becauſe they perform their changes in a dark and myſterious manner, which nothing but the indefatigable diligence and attention of the curious can bring to light. It is owing to this that theſe inſects have been hitherto treated, not according to the laws common to other animals, in which the great Creator has been pleaſed more openly to maniſeſt his glory, but according to falſe notions, ſuggeſted by our human ignorance and prejudice. I muſt here, however, do juſtice to the illuſtrious Redi, who has treated the works of nature in a very different manner, and thereby reſcued the operations of that great but ſubordinate agent, from thoſe thick clouds of darkneſs which human error and ignorance had raiſed about them: by what other name can we call that abſurd opinion, which attributes every thing to chance and putrefaction. Certainly, whatever allowances we may make on this occaſion, to the generality of mankind, thoſe among them, who would be thought people of ſenſe and learning, are altogether inexcuſable in countenancing ſuch a thought. This groſs error is the natural conſequence of mens manner of proceeding, when contented with ſitting quietly in their ſtudies, and looking over books; they neglect to trace the ways of God, the great Author of all things, in his works, which ſurround us on every ſide, neglecting them, to follow the deluſions of their own feeble imaginations.

The cavities now mentioned, are ſometimes found to the number of ninety, or even a hundred, or more, growing through one another, and wrapped about in the woolly down, or cottony matter that is lodged in the ſame place. When the Worms, encloſed in them, have changed to Nymphs, and afterwards acquired their proper degree of ſtrength, they each throw off a delicate ſkin, and are thus turned to very ſmall Flies; then they bore with their teeth through both the little tubes in which they hitherto have lain concealed, and the down that ſurrounds them, and then iſſue forth at a great many openings, Tab. XLV. Fig. VI. *ee*, in a very entertaining manner. On this occaſion, ignorant ſpectators are loſt in wonder, and form to themſelves variety of ſyſtems to explain ſo unuſual an appearance; but when they come to relate their opinions, we generally find them void of reaſon, and altogether ridiculous.

The Fly produced from theſe Worms, is divided into a head, thorax, and body, Fig. VIII. *f*. The head is furniſhed with eyes, and it has two long antennæ. From the upper part of the thorax ſpring four membranaceous wings, that ſhine like mother of pearl, and the upper pair are adorned alſo with two black ſpots, and with ſeveral very pretty ramifications of the nerves. To the under part of the thorax are fixed ſix tranſparent legs of a delicate rediſh brown colour. The body conſiſts of ſeveral rings, and is armed, at its extremity, with a weapon of an oblong form that is plainly diſcernible: no doubt, this is the inſtrument with which the inſect pierces the Oak branches, in order to depoſit its eggs within their ſubſtance. This Fly is altogether black in the body. I have not yet had the good fortune of diſcovering its eggs, either in the excreſcencies wherein they are hatched, nor in the body of the female, as I never have diſſected any of them. I made the foregoing obſervations on the 26th of June, when a great many of theſe ſurpriſing Flies iſſued from their neſts, which they likewiſe continued to do, till the 8th of July. The males were ſmaller than the females.

Of

Of ſome little inſects that are found concealed in the tubercules, or ſwellings of Oak-leaves, in ſo artful and wonderful a manner, that the foregoing relations muſt yield the preference to their hiſtory.

THE obſervation I am now about to exhibit, is ſo uncommon in its kind, that nature perhaps cannot furniſh any thing to excel it. On this occaſion the infinite power and wiſdom of the Great Sovereign of the univerſe ſtrikes our eyes with its full luſtre, and indeed ſo plainly ſhine forth in his creatures, that we muſt conſider the meaneſt of them as ſo many voices engaged in publiſhing his praiſe; and thereby putting us in mind to yield him that tribute of love and adoration, which we owe on ſo many accounts: us, I ſay, on whom he has beſtowed the ineſtimable faculties neceſſary to inveſtigate and conſider him in his works.

To proceed with due order in this relation, I ſhall firſt deſcribe the excreſcences of the Oak-leaves, in which theſe wonders are found *, and add a figure to render the deſcription more intelligible. I ſhall then, in the ſame manner, give a ſatisfactory account of the inſect bred in theſe excreſcences, as it appears in the Worm, Nymph, and Fly-ſtate. As to the excreſcences themſelves, the particulars in them moſt worthy of our attention, are their ſituation, conſtruction, figure, colour, and ſize. Their ſituation is irregular, and it is pretty like that of the excreſcences on nettle-leaves already deſcribed. Some lie on the fore part of the leaf, upon or cloſe along the ſides of its nerves or ribs, Tab. XLV. Fig. XII. *aa.* Others appear in the middle of a leaf, ſeated upon the main rib, *b.* And ſome, in fine, are ſcattered confuſedly about the edges, *cc.*

Theſe tubercles conſiſt of a hard, knotty, and compact, but brittle, ſubſtance, without the leaſt toughneſs; ſo that, in this reſpect, they very much reſemble a cartilage. But, upon the whole, I know nothing to which this ſubſtance may be more juſtly compared, than to the cup or covering of the hazel-nut or filbert, before it ripens, or has been pulled. Theſe tubercles, or ſwellings, are formed between the two coats of the oak-leaf, and acquire their hardneſs when the delicate parent Fly has buried its eggs there. Theſe tubercles are ſometimes round, ſometimes oval or oblong; and we often meet with two, three, or four of them growing into one, ſo as, in a manner, to compoſe but one continued body. Their colour is generally a deep green, ſometimes a watery ſky-blue, and in ſome inclining to white and yellow. In point of ſize they differ greatly, according to their age, or perfection of growth, and their joining two or more into one tubercle, *b.*

I have not as yet had the ſatisfaction of ſeeing the firſt rudiments of theſe tubercles, which firſt I took notice of by mere chance, in company with my much honoured friends, the principal magiſtrate of Niewenrode and his lady, in the Hague-wood, from whence I took many of them home to examine at my leiſure. I ſhall, therefore, now deſcribe thoſe wonders I obſerved in them, in the courſe of a moſt diligent inquiry. In one of the largeſt of theſe tubercles, which I opened by paring off its upper part, Fig. XIII. *d,* I found a pretty large cavity, in which there again appeared three other peculiar or ſeparate excreſcences, *e.* As to the manner of their coming there, it is more than I can conceive. Theſe ſmaller excreſcences lay ſingly each within a kind of hollow, but without any partition between them. On taking out theſe three ſeparate excreſcences, *f,* I found that in figure they greatly reſembled a kidney-bean, which has one ſide more convex than the other. On inſpecting them with a microſcope, they looked as if they had been connected by the middle to a kind of pod, by means of a petiolus, or little ſtalk.

Theſe ſingularities ſerved only to make my curioſity more eager, to examine attentively the other tubercles that I had taken home with me; and I found them all filled with the miracles of the Great Creator. On ſeparating in the middle a tubercle, that wanted a great deal of being arrived at the ſize and perfection of that already deſcribed, I found no hollow or void ſpace within it; but only two ſuch pea-ſhaped ſubſtances as I have before taken notice of, and two little Worms, which I had cut in two, along with thoſe ſubſtances. All this is plainly ſhewn in the figure I give of them, Tab. XLV. Fig. XIV. little larger than nature; in which may be ſeen the two diſſected or cut ſubſtances, ſituated in the middle, and about them the ſubſtance of the tubercle, by which they are cloſely ſurrounded, like the ſeeds of an orange by its pulp. I could likewiſe obſerve, that the external coat or ſhell of the tubercle was much more compact, and of a greener colour, than the inſide; which difference I have endeavoured to repreſent in the figure, as if there had been a ſeparation between the differing ſubſtances, though, in reality, there is no ſeparation in this ſtate of the production.

On opening a third tubercle, that was ſomewhat more grown, I could diſcern that its internal ſubſtance was drying up by degrees, and

* The Worms found in tubercles of leaves, and other parts of plants, are all owing to the eggs of winged inſects. Their parents are of three kinds: 1. Butterflies. 2. Beetles. 3. Flies. We may know, at ſight, to which of theſe kinds any Worm belongs by its form. If it have no feet or legs, it is the Maggot of a Fly. If it have ſix legs, and no more, it is produced from a Beetle, and will be changed to one. If it have more legs than this number, it is a Caterpillar in miniature, and will change to a Butterfly or Moth.

feparating from the enclofed kidney-bean-like fubftance; by which means this came at laft to lie in the tubercle as within a hollow, and to reft againft one fide or another of this hollow. In this manner I plainly difcovered, that the three detached fubftances, in the tubercle I firft opened, had obtained, by evaporation, that wonderfully elegant fituation in which I found them. This difcovery was afterwards confirmed by all the other tubercles, and their internal fubftances. On my firft obferving thefe furprifing changes, without knowing the ends which Nature intended to anfwer by them, I looked upon the whole as a moft inexplicable riddle; as did likewife the ingenious perfons then in my company: for our walk was made merely with a view of regaling ourfelves, together with a contemplation of the ftupenduous miracles of the Univerfal Parent.

We find in nature many other things, which agree and correfpond with what I have been juft now relating. The feeds of apples and pears, buried within the flefh of their refpective fruits, fall off, little by little, from their coats and cups. The fame thing is obfervable in the kernels of filberts when they grow dry, and even in the nut itfelf or filbert, which at laft drops from its cup. But what is altogether fingular and uncommon, in the tubercle now under confideration, is, that this fubftance, which feparates from it, and lies loofe within its body, fhould contain a living Worm.

When thefe fubftances, in confequence of the hollow occafioned in the tubercle by a large evaporation, have newly become loofed from it, their circumference is fomewhat rough and uneven; but as it dries, it grows even and fmooth to the naked eyes: but the microfcope always difcovers on the furface the remains of the former ruggednefs, Tab. XLV. Fig. xv. *g*. In the fame manner the fpot, at which this fubftance received its nourifhment, never entirely difappears; but remains difcernible to the laft, in the form of a little cicatrix or fcar, *h*.

The fubftance of thefe internal nodules is at firft foft and tender; but it afterwards hardens and dries up, and affumes a brownifh red colour, which it never afterwards lofes; fo that, when viewed within the hollow of its green tubercle, it affords a moft pleafing fpectacle. When thoroughly dried, it is of a pretty compact and firm texture; and in refpect to its coat or cruft, it greatly refembles the rind of a chefnut, only this laft is much thicker. But neither thefe fubftances, nor the Worms they contain, are all of the fame fize.

Likewife the number of thefe contained within the tubercles, varies greatly. In fingle tubercles, every one lies by itfelf in its own particular hollow; but it is the reverfe in the double or more compofed tubercles. Sometimes alfo, though three or four tubercles grow in one, all their inner fubftances have notwithftanding each its own little cell, feparated by a kind of diaphragm or divifion. The fpots on which thefe fubftances grow within the tubercles, is generally a little moift or damp, which keeps them from rolling about. The cavities alfo of the tubercles differ in fize, which I attribute to the tubercles themfelves having been fome bigger than others, or to their having been dried up in different degrees. But, in general, there is found only one detached fubftance in every tubercle.

On opening one of thefe fubftances, that I had taken out of its tubercle, I found in it a living Worm, compofed of many rings, as I have reprefented it, larger than nature, on the middle of the Oak-leaf, Tab. XLV. Fig. XII. *m*. The figure of this Worm was oblong, and its colour white. On its back appeared a gray ftreak, approaching to black; which I afterwards, on diffecting the Worm, found to be no other than one of its inteftines, which appeared through its tranfparent fkin, and owed its colour to the half-digefted food which it contained. In other Worms this ftreak was fometimes brown, fometimes red, yellow, or green, owing to the caufe already affigned. This little Worm lay in its bean-like fubftance in the form of a crefcent, quite free and loofe on every fide. I could not even difcover in it any umbilical veffels, or other connecting filaments, by which, according to the vulgar opinion, it might have drawn in its food. It moved and turned itfelf about at pleafure in this little habitation, being very vigorous and lively. There appeared no excrements in the cell, nor yet the leaft opening by which it could empty them. The hollows of the tubercles were equally free from any foulnefs of that kind: every place was perfectly neat and clean.

Neverthelefs I fhall not deny that this little infect received nourifhment within its covering, fince the contrary is plainly feen from the altered food which appeared in its inteftines, in the form of excrements. Hence I conclude, as a certainty, that this Worm fubfifted on the juices of the Oak-leaf, which were conveyed into the cavity of the fubftance by its ftalk, and that it took in thefe juices with its mouth. As this aliment, no doubt, is of the moft refined kind, there is the lefs reafon to wonder at the Worm's not voiding any excrements, in confequence of its ufing fo fine a nourifhment. On the contrary, retaining within its body the little that was fecreted, till an opportunity offered of difcharging it all together, when it fhould be turned to a Fly in due courfe of time, and freed from its confinement. It is common with feveral infects, produced from Nymphs and Chryfallides, to evacuate their excrements very copioufly, within the firft quarter of an hour after their appearing in the Fly-ftate. Nor is there any reafon to wonder at a creature's being able to grow without difcharging any excrements, fince new-born Lambs and Calves furnifh us daily inftances of this kind. Thefe animals never void any excrements at the anus, till they are dropped from their mothers *.

I think it probable that the ſubſtance of the tubercles does not begin to dry up, till the encloſed Worm, having attained the full term of its growth, becomes mature and ready for the Nymph-ſtate; and even at this time, the lower part of the ſubſtance ſtill continues moiſt, ſo that the encloſed inſect may, at this period, alſo draw nouriſhment through it, from the aſcending juices of the tree, in caſe it ſhould happen to require any. Thus we have another inſtance of God's all-ſeeing providence, which, with ſo much goodneſs, watches inceſſantly over his creatures; and this inſtance is the more ſtriking, as the lower part of the bean-like ſubſtance grows looſer and drier by degrees, on the Worm's actually entering into the Nymph-ſtate; ſo that the moiſture I have been ſpeaking of, begins little by little to dry away, when the time approaches for this Nymph to appear abroad in the Fly-form. Sometimes indeed the detached ſubſtances, at this period, are found quite looſe in the cavities of their tubercles.

One of theſe Worms, which I had extracted from its bean-like ſubſtance, lived, notwithſtanding, from the fifth of June to the fifth of July. When the Worm has received ſufficient nouriſhment, it draws the rings of its body cloſer to each other, Tab. XLV. Fig. XVI. It after this caſts a delicate ſkin, and at length aſſumes the form of a Nymph, which is at firſt white all over, but grows blacker and blacker by degrees, in the ſame proportion as the encloſed limbs of the future Fly acquire ſufficient ſtrength to expand and produce themſelves. At this time, there very plainly appear on the Nymph's head, two reticulated or net-like eyes, Tab. XLV. Fig. XVII. *a a*, and underneath in the thorax, the two teeth, which were before diſcernible in the Worm. Along the body lie the antennæ, *b b*, and between them the ſix legs, and the wings neatly folded up. The rings of the body ſhow themſelves very diſtinctly in the lower part, *c*. I refer this Nymph to the firſt mode of the third order of natural mutations, as it clearly repreſents the limbs of the future Fly, in the ſame manner with the Nymph of the Ant.

The two figures I give of this Nymph repreſent it, one of its natural ſize, Fig. XVIII. the other as it appeared through the microſcope, Fig. XIX. It is divided into the head, breaſt and body. The eyes are ſeated in the head, and before them are placed two moderately long antennæ, *a a*. The breaſt bears four wings, *b b*; the upper pair, which are the largeſt, are ſtretched over the body; to the under part of the breaſt, are articulated ſix red legs, each armed at its extremity with two claws, *c c*. The belly of the females is thick, ſwollen, or diſtended; but it terminates in a ſharp point, *d*, which perhaps the creature makes uſe of as a weapon, to bore the Oak leaf, and afterwards as a channel to convey the eggs into the hole made in that manner. The ſurface of the body is ſmooth all over, as if poliſhed, and is of a ſhining deep black, which gives the Worm a pretty appearance. Theſe Flies broke from their confinement the 28th of June; but I diſſected none of them, ſo that I can ſay nothing of their eggs, or of their genital parts.

We are now to conſider another wonder, equal to any of thoſe I have yet related; and this is the ſingular and uncommon manner in which the all-wiſe, and all-powerful Architect has provided for the delivery of theſe Flies, without their meeting with any oppoſition. At the time the Worm has attained the Nymph-form, the encloſing tubercle begins to grow thinner and thinner by degrees, at a certain determinate and ſelect ſpot. This circumſtance I have endeavoured to repreſent in a tubercle, where I found two detached ſubſtances, Fig. XX. *i i*; nor is Nature content with only reducing the thickneſs of the tubercle in this manner; but ſhe likewiſe ordains things, ſo that it dries up and hardens in the ſame place, in order to make the perforation of it, by the teeth of the Fly, eaſier than it otherwiſe would be. The little priſoner, on its becoming a Fly, firſt gnaws through the inner ſubſtance, and then through the tubercle itſelf, a round hole, Tab. XLV. Fig. XII. *k*, juſt large enough to afford it a free paſſage to its new element.

We may know of a certainty, when theſe inſects are about to turn to Flies; for the dry ſpots at which the Flies are to make their way, appear very obviouſly on the ſurface of the tubercles, *l l*. On inſpecting theſe tubercles again, a few days after the 28th of June, I found many of them perforated, and that the Flies bred in them had made their eſcape, ſo that nothing remained in them but the detached ſubſtances, which were likewiſe perforated. The tubercles wrinkle and wither away, for the moſt part, on their inhabitants quitting them. Theſe wonders all return with the ſucceeding year, and thus call upon us without ceaſing, to publiſh the praiſes of their Author, who has openly manifeſted Himſelf in all his creatures, and has given to man alone, amongſt all ſublunary beings, the faculty of knowing Him. In what a bad light therefore muſt thoſe appear, who, unaccountably blinded by their ignorance, dare to oppoſe the exiſtence of that all-watchful and adorable Providence, by fooliſh arguments! Behaving in this manner, and working their own deſtruction, they debaſe themſelves below the rank even of beaſts, and deſerve to be conſidered as monſters in the nature of things.

* Beſide thoſe Worms which proceed from eggs let into the ſubſtance of the leaf by the parent Fly, there are ſome, both of the Fly and Butterfly kind, which only drop their eggs upon the ſurface of the leaf, and faſten it on by a glutinous matter. The Worms and Caterpillars hatched from theſe, the moment they burſt from the egg, make their way through the outer coat of the leaf, and get into the ſubſtance. They thus live under cover till they change.

Of

Of certain Worms that feed within the ſpongy excreſcence of the Dog-roſe.

THE excreſcence of the Dog-roſe, as to its external appearance, is not altogether unlike that of the Oak repreſented in Fig. VI. of this plate, though it is not of a woolly, but on the contrary, of a ſpungy ſubſtance, in ſo much that it may, with great propriety, be called the ſpunge of this ſhrub. The colour, when dried, is a blackiſh gray; and in the ſame ſtate, the ſurface of it is full of little cavities and prominencies, Fig. IX. *aa*. It grows as the other, at the extremities of the branches, where it ſtands upon the center, juſt as the bud of the Roſe does upon its ſtalk *b*. On opening this excreſcence, we find in it a great many cells, Fig. X. *c*, full of little white Worms of different ſizes and ages. Theſe Worms aſſume, by degrees, the Nymph-form, in the ſame manner with all the Worms living in excreſcences, that I have hitherto mentioned; and under this form they moſt manifeſtly exhibit the limbs of the future Fly: this happens about the end of ſummer.

I had the pleaſure of obſerving two ſpecies of Flies iſſue out of theſe ſpunges, thro' holes they had made in them for that purpoſe. The firſt ſpecies was not unlike the Flies that had been produced, at my houſe, from the tubercles of the Oak, only, that they had ſomewhat thicker bodies, Tab. XLV. Fig. XI. *d*, with black eyes, and all the reſt of them was of a rediſh brown colour. The other ſpecies *e* were of the Bifetæus kind, or had two hairs at the tail, though this character was peculiar to the males. They had likewiſe, in common with the firſt ſpecies, four wings and ſix red legs. Their bodies were oblong; and their heads, which hung to the thorax by a very ſlender neck, were furniſhed with a pair of rediſh eyes. Their bodies all over ſhone like thoſe of the Cantharides, or Spaniſh Flies, with a gilded green, ſo as to afford a very entertaining ſpectacle. Theſe Flies did not all appear abroad at the ſame time, but were employed for ſeveral days ſucceſſively in making themſelves openings in their habitations: this they effected by gnawing the ſpungy ſubſtance with their teeth, into a great variety of holes and cavities, Fig. IX. *f*.

A careful and exact obſervation which I made on the tenth of July, 1674, on the black Poplar, in preſence of the principal magiſtrate of Nieuwenrode, and his lady; both very curious in examining the natural wonders of the creation.

THOUGH all the works of the Almighty are wonderful, we may obſerve, that ſome publiſh his praiſes more manifeſtly than others. This appears moſt eminently in the various organs of generations beſtowed upon animals, and the different manner in which they uſe them; for ſome declare, by evident and intelligible characters, the power and contrivance of the great Architect, whereas others repreſent it by marks that are ſomewhat obſcure and myſterious.

On the tenth of July, 1674, as we were going in a chariot to Scheveling, we ſaw ſome red fruit like Cherries hanging from the leaves of the Poplar-tree, in ſuch numbers, that they could not but ſtrike the eyes of all that paſſed by. When we viewed them near, it appeared to us, that they were ſo many rough tubercles, or extuberances, on the leaves of thoſe trees, Tab. XLV. Fig. XXI. *a*, each of which, when opened, ſhewed a great number of living inſects, to the amount of 60 or 70. Thoſe warts, or protuberances, which projected above the ſurface of the external coat of the leaves, were ſituated exactly under the middle of the nerves or ribs; ſo that theſe nerves paſſed *b* over them; being ſometimes a little higher, and ſometimes lower, according as the warts themſelves projected, more or leſs, without any order from the leaf. Two warts were likewiſe ſometimes found, but very ſeldom, on the ſame leaf. Their ſize greatly differed; ſome of them, as if young, were ſmaller; others larger and more ſwollen; a third kind alſo grew ſtill larger and higher than all the others. When we firſt ſaw theſe tubercles, we thought they were every way ſhut up or incloſed: but upon a more accurate examination, we found, that each of them had, on the inſide of the leaf, where they were ſmooth, an orifice *c* ſomewhat long, thro' which the inſect paſſed at pleaſure.

It is worth notice, that the leaf always ſwelled under its largeſt nerve, which it conſtantly elevated; and likewiſe, that this tumor was only found about the nerve, and in the middle of the leaf. The reaſon of theſe circumſtances ſeemed to us to conſiſt in this; that the eggs of the inſect-inhabitants had been impreſſed on that place only, and that the nutritious juice of the leaf was for the moſt part conveyed thither. Thus it might eaſily happen, that the leaf might be there increaſed and inflated by the nutritious juice accumulated by the irritation which had been produced by the lodging of the eggs in the ſubſtance. And hence alſo we obſerved plainly, that the whole wart on the leaf was nothing elſe but a larger dilatation and expanſion of the leaf itſelf; which cauſed the nerve, puſhed out at the ſame time, to be twiſted into various bendings and windings, which were very conſiderable *dd* in ſome of them.

It deſerved great conſideration to obſerve how regularly all theſe things are done. For when the leaf is newly ſtruck and begins to ſwell,

ſwell, it firſt grows yellow, and thence inſenſibly red, and is at length expanded like a bag, or a hollowed Cherry. In the mean time, the two edges of this extuberance grow ſo exactly oppoſite to each other on the inſide of the leaf, and are, as it were, ſo united together, that the opening, or chink can ſcarce be perceived. This is regularly appointed in that manner by the Almighty, in the nature of things, leſt the eggs or the young Worms ſhould fall out of this their cells, or lodgings, or ſhould creep out before they have attained their full perfection, and are become able to fly. We have now ſaid enough of the external form of theſe tubercles.

When we afterwards opened them, we found in the inſide the following very obſervable circumſtances: in ſome we ſaw Flies full grown; in others, Worms with ſix feet, which were real Nymphs of the ſecond order; and alſo ſome Worms, which, not yet exhibiting the limbs of a Nymph, were only in their firſt growth. We alſo diſcovered there a downy white ſubſtance, and ſome tough fluids, which ſeemed to be encloſed in the membrane.

To treat of each of theſe in their order, I ſhall firſt obſerve, that we found the inner ſurface of theſe warts more ſmooth and flat, than the outward. We thought the reaſon of this difference was, that in the external ſurface of the warts, the ſmaller nerves, which are there diſtributed thro' the leaf, were dilated and extended with the reſt. As to the paleneſs of the colour, we conceived, that the reaſon of it conſiſted in this, that the whole inner ſurface appeared ſprinkled, as it were, with meal and ſmall white grains of bran formed like down. From whence this downy matter draws its origin, we ſhall examine preſently. We ſometimes obſerved ſomething, tho' but little, and that not frequently, of a roughneſs in the cavities of the warts: but whether the cauſe of this was, that the old Flies, remaining there for ſome time, had ſcratched the ſurface with the claws on their feet, we could not certainly affirm.

The ſmalleſt Worms we found within theſe warts, were each divided, like perfect Flies, into the head, thorax and belly, Tab. XLV. Fig. XXII. In the head were ſeen two eyes and two antennæ. To the lower part of the thorax ſix legs were articulated. The reſt of the body was ſomewhat ſhort. They appeared to the naked eye of an azure or fine blue, but greeniſh under the microſcope. They caſt a ſkin in like manner as the other ſpecies of Worms. They alſo moved very quick, and were much more vigorous than the larger Worms, or than thoſe that were already changed into Flies.

What deſerves moſt obſervation in theſe little inſects, is a heap of flocks or down, which each very beautifully and admirably carries *e* on the hinder extremity of its body. Whether that down grows out of the very body of the inſect; which indeed is very likely, or whether it be produced from the tubercle or wart, and afterwards is lodged in the hinder part of the body of the Worm, we could by no means diſcover; tho' we were moſt inclined to think, that the down grew from the body of the inſect, becauſe we no where ſaw it ſticking to the bodies of the more mature ones.

In certain Worms, with ſoft bodies, that live expoſed to the ſun upon the leaves of the Lilies, I have obſerved, that they heap together all their excrements on the hinder-part of their body.

In others that lived among the leaves of Thiſtles, I have obſerved two ſtiff briſtly hairs ſtanding in the hinder-part of the body; on which was always fixed the ſkin which the inſect had caſt off, together with ſome excrements. Thus they lie under their ſkin, as under a pent-houſe, free from the ſun's heat, and walk up and down with it among the leaves. The firſt ſpecies of theſe Worms, at length, changes into a Beetle, of an orange red colour, with black horns and legs; but the other into a large Tortoiſe-beetle, in like manner, with black legs and a black body. Theſe two very extraordinary contrivances do not much differ, with reſpect to the down, from that which the inſect, whereof we here treat, carries on the hinder part of the body. We may likewiſe ſee from hence what miſeries all creatures are ſubject to in this vale of filth and calamities, finiſhing their lives continually under unhappineſs and misfortunes.

The whole inner cavity of the wart, as I have already mentioned, is ſet as it were, or rather ſprinkled over, with that farinaceous down. And this, doubtleſs proceeds from the exuviæ, which the inſect contained in it has caſt off. At the time they caſt the ſkin and this down together, they diffuſe it every where about by running up and down. This downy ſubſtance is very elegantly divided into branches, and greatly reſembles that ſpecies of nitre which riſes out of walls newly built in ſome parts of Holland: when viewed with a microſcope, it ſeems like the ſmaller or branched moſs of trees.

As to the food of theſe Worms, it is very hard to demonſtrate what it is: however, it is very certain, that they are nouriſhed within the cavity of their warts. Probably, that white, tenacious, and glutinous moiſture which I have before ſhewn to be ſecreted within the warts. Hence, that humour is ſo admirably ordered by the all-wiſe Creator, that it never flows away, nor does it wet, nor can it ſuffocate theſe little creatures. As it is ropy and clammy, the down immediately adheres to it, and performs the buſineſs of a membrane or bag, in which, as in a cloſe veſſel with a ſpout, it lies encloſed, and cannot run out of it.

I compare them to thoſe cloſe veſſels, becauſe there are ſome of theſe bags of that figure, Tab. XLV. Fig. XXIII. *f.* and by means of a hollow footſtalk, are fixed to the ſurface of the wart, where the humours, juſt now deſcribed, probably flows out of that excreſcence. Therefore, this is probably the real and only uſe the ſaid down is of to theſe warts, and to the

the little creatures, it ferves to confine the moifture. When this moifture is confumed, the downy integuments, which furrounded it outwardly, become curled *g* into each other like preffed flocks of cotton; and therefore feveral fuch downy clufters are found gathered together in the warts.

The bags juft now mentioned, containing a fluid, are all furnifhed with a petioli, or footftalk, by means of which they adhere to the inner furface of the tubercle: but whether that fluid be the real aliment with which the Worms are nourifhed, according to my opinion, or whether they are there fed with fome other matter, has not hitherto appeared to us from experience. But this is certain, that thefe Worms have neither a trunk, nor any teeth. Nature hath given them only an acute and delicate converging beak, not unlike that of the Cicada, which fucks the dew: by this beak they can penetrate eafily enough thro' the downy coat of their bags, and fuck the moifture before defcribed. But whether thefe creatures do really nourifh themfelves in this manner, or not, I cannot yet affirm, tho' it is very probable.

We poured a fmall drop of water into the cavity of thefe warts; and it was immediately covered round with that farinaceous down, and was deprived of its fluidity to fuch a degree, that when it was afterwards fhaken on dry paper, it did not wet it, but flipt and rolled over it, and did not ftick to it: this was a very agreeable fight.

There is not fuch a great quantity of that down about the largeft, as about the fmalleft Worms. On thefe indeed there grew four buds or rudiments of coverings of legs, on each fide near the fhoulder-blades. I have reprefented them *hh* on each fide of the thorax, above the hinder legs. The principal cafes, or firft buds of the limbs are, in reality, a kind of covers, in which the wings lie folded up. Therefore, thefe creatures may then be properly called Nymphs belonging to our fecond order of natutural tranfmutations; for in that order, the infects do not at all lofe their motion during the time whilft they are changing into Nymphs; but on the contrary, walk, ftand, eat, and move about, until they change their skin; and having at length caft their exuviæ, they affume, as it were, another ftructure, and acquire only wings. This muft be well obferved. I would likewife have it remembered, that I have ranked thefe Nymphs in the fecond order, becaufe they perform their change in fo obfcure a manner, in the warts of the leaves.

Thefe Nymphs, which are to change, caft a very fine skin or integument, which is left in the cavity of the wart *. When this is caft, they acquire, Fig. xxv. the form of delicate fmall Flies, with four wings. Thefe Flies are of a blackifh colour, except the membranaceous wings, which have brown nerves, and elfewhere approach fomewhat to red. The limbs, and other parts, that is, the head, thorax, abdomen, antennæ, eyes, legs, and the reft, may be now feen much more diftinctly in the infect, now perfectly mature, than when it appeared in the form of a fix-footed Worm.

The horns appear to be divided into fix joints, and are very beaatiful; they are compofed, as it were, of grape-ftones, or are like a fmall piece of cinnamon, incruftated or rough-caft with fugar. The eyes are confiderably large, and reticulated; they appear very diftinctly when the creature lies on its back. The beak is clofely applied to the lower part of the thorax, and is there feen extended downwards between the firft pair of legs, juft in the fame manner as the Cicada. The wings, befides their nerves, and the veffels, wherewith they are elegantly diftinguifhed, exhibit two oblong black fpots, with which they are ornamented.

This creature flies very flow; indeed it does not move with fo much fwiftnefs as the fmall Worm, out of which it is produced. I have not yet difcovered, by diffection, the difference between the male and female; nor have I ever feen the eggs of this Fly. I am inclined, however, to think, that they are lodged by the parent, on the inner coat of the Poplar-leaf: and that the wart or tubercle here defcribed, is afterwards formed there by nature, in order to hatch and nourifh them, and to keep them in fafety. But how all thefe things are performed, we can yet only conjecture: fince they muft be known, not by reafoning, but from folid experiments. I fhall here therefore furl my fails, and in amazement, celebrate the great Creator, who hath hidden fo many, and fuch inexhauftible natural and important miracles, full of true knowledge and erudition, in his creatures; fo that the air, the water, and the earth; the plants alfo, that vegetate therein, abound with them; and all vegetables and animals, however fmall, proclaim the glory of the Supreme Being.

* The modern term for all Worms bred from the eggs of winged infects in tubercles, or parts of vegetables, is Afcarides. Reaumer is the author who eftablifhed this. Some of them burrow deeper, others very flightly; all get under cover of the upper membrane. The manner of their getting through it, when their parent infects have lodged them on the furface, is various; the Caterpillar kind eat their way; the Worms of Beetles get in by breaking the furface with blows of their head.

Of the footless Worm of Cabbage-leaves, which properly belongs to the fourth order or class of natural changes.

ON the 15th of August, I found on Cabbage leaves several footless Worms, and some of their Nymphs. The body of the Worms, was in the fore part somewhat pointed, but in the hinder part a little thicker, Tab. XLV. Fig. XXVI. They were also divided into annular segments, which appeared in the skin like so many small incisions. They were of a pale green colour; but they appeared variegated, by means of certain white viscera, which were seen through the transparent skin. This creature was by nature very slow and heavy, though, when touched, it shewed greater agility and sprightliness. Whether it uses Cabbage leaves for food, or hunts there after some green little six-footed insects, which are at length changed into Nymphs of the second order, and from the latter into Flies; I have not accurately investigated: I know some are of this last opinion. This Worm usually stretches aloft the fore part of its body, in the same manner as an Elephant does its trunk, when it first begins to move and go forward. Therefore, I do not doubt, but it is the very creature which Goedaert described, Exper. XI. part II.

When this Worm hath at length fed enough, and its internal parts have acquired sufficient strength to put on the form of a Nymph, it is then changed, Tab. XLV. Fig. XXVII. and XXVIII. into a real Nymph of the fourth order; which change is performed in the following manner: We first observe, that the Worm, before it casts any skin, becomes insensibly shorter; that its head is entirely contracted on the inside, and at the same time it becomes thicker; but the hinder part, by degrees, grows smaller, and more slender, the body thus loses its former figure. For the blood, and all the fluids, are propelled forward to the new parts, which are now increased, and swollen under the Worm's uncast skin, and appear divided into the head, eyes, thorax, legs, wings, and body: this may be clearly seen, if this Nymph be artificially stript of its yet uncast skin. One may likewise see the several particulars beforementioned through the skin itself; when the Nymph, being some days old, begins to acquire its proper colours.

As the colour of the Nymph, on the change is white, and is afterwards altered into a green, mixed with a pellucid white; the red eyes in the head appear, Fig. XXVIII. *a a*, gradually through the transparent skin. The same thing holds, *b*, in regard to the thorax, which exhibits some pellucid hairs on its surface. In the hinder part of the body, the abdomen is seen through the skin, divided *c c c* into several rings, which are likewise set with small hairs. On one side of the body is seen a wing *d* somewhat pellucid. Towards the hinder parts, and near the tail a curled little vessel, Tab. XLV. Fig. XXVIII. *e*, which indeed seemed to me to be a pulmonary tube rolled out.

When this Nymph is grown older, and at length becomes all coloured, then these parts appear most distinctly, if the skin be taken off: this will be evident from the magnified figure thereof, which I have given here. In this are discovered, Fig. XXIX. *a*, the Nymph's reticulated eyes; above and between which are two short *b* horns. The proboscis or trunk is laid along the breast *c*, and near it, the first and second pair of the fore legs, are seen to be beautifully disposed. On each side of the breast lie the folded wings, *d d*, and under them the last pair of legs, *e*. What deserved the greatest notice in this creature was, that the extremities of the genital parts, were placed, *f f*, as it were, beyond the rings of the body, and terminated in shaggy points: which are at length drawn into the body, when the Nymph puts on the form of a Fly.

This Nymph is therefore a very uncommon one; and though properly referred to the fourth order, yet it undergoes considerable changes, and exhibits no more of its former shape than the skin only, which it does not cast, but retains. The reason why this Nymph so much differs from others, of the same order is, because it is invested with a tender and thin skin, which obsequiously accommodates itself to the growing and protuberant limbs within. All this I have explained in the preceding pages, where I treated expresly of the nature of the fourth order. We must further observe, that this Worm, when changing, is not disengaged from the Cabbage leaf, as is the case in regard to many other insects: on the contrary, it first glues itself thereto by a viscous matter, which appears Fig. XXVIII. *f f*, like a thin membrane on the leaf.

The Worm having had this form sixteen or seventeen days, the hidden Nymph then breaks open, and casts off the outward skin, and at the same time draws a thin film off from the whole body, and from all the limbs, which is left on the inside in the old skin. Thus the Nymph appears, Fig. XXX. at length under the form of a Fly. The young Fly is much smaller at first, than in a quarter of an hour afterwards; for its parts are in that time insensibly extended, particularly about the head and belly, so that the Fly becomes almost twice as large, in so short a time after it is produced; after which it never increases any more. If any one would know the reason how the body of this Fly is so remarkably distended, it will appear, on examination, that it consists in respiration, which fills all the pulmonary tubes, and pneumatic bladders with air; and these, on the other hand, expand the hitherto soft body of the creature, and give it a firm and durable figure.

This Fly is beautifully divided into the head, thorax and abdomen, and has six legs and two wings. Behind these, two little parts are observed to be fixed to the thorax, supported, as it were, by two fine footstalks, with their extremities headed;

headed; fo that they refemble two little hammers, which, the Fly ftriking againft the wings, forms the noife peculiar to it. The eyes are ruddy, the thorax is greenifh; the abdomen, on the contrary, is yellowifh, and is variegated with blackifh hairy wreaths.

I have often feen inftead of the Fly, which is commonly produced from the Worm before defcribed, eight other Flies iffuing out of its Nymph, which had indeed drawn their origin from the Worms that feed on the internal parts of that Nymph, and were changed within it, into fo many fmall Nymphs. When thefe little Nymphs had at length grown into Flies, they flew out, after piercing the fkin of the larger Nymph. Thefe Flies had each fix red legs, four wings, and a body that glittered with a golden and very lively green, excelling the light of the fun's rays.

Of the Worms called Moths.

THOUGH the Moth is a very common creature, yet few know it; for it lies hid, and does not exhibit itfelf to open view; for that reafon it is the more mifchievous. Moths are in reality Vermicles, or Worms that live in woven cells, at all times, except when they build their nefts, in wool, fkins, or birds feathers: in thofe cafes, they ufually build themfelves irregular cells, becaufe they have both the habitation and food, which they then irregularly grind with their teeth, always ready.

They build their habitations very artificially, fo that they are always larger in the middle, and narrower, Tab. XLV. Fig. XXXI. *a*, on each fide, where the paffage is: and that ftructure does this fervice to the Moth, that it can the more conveniently turn itfelf in the middle of its habitation, and go out through either orifice when neceffary. It is alfo obferved fometimes, that the Moth fpins a fine thread, efpecially when it creeps near the walls and beams of houfes, feeking its food there; for this is of various kinds. In that cafe it forms this thread, to prevent falling down, when it ceafes working, and goes into its cell; for at that time only it hangs fufpended, *b*, from the thread. I have likewife often feen, that the Moth fpins this thread, when the anterior or forepart of its body has firft crept *c* out of its little cafe, and endeavoured to fix itfelf fomewhere by means of it: but when the creature was afterwards inclined to proceed further, it broke this thread, and going out of either opening of its cell, fixed it again in another place: and when this is done againft a beam or wall, it forms a very beautiful fight.

In order to defcribe more particularly the little Moth, which I here exhibit in its natural fize; I muft obferve, that with refpect to its ftructure, it is not unlike a fmall Caterpillar. It has a glittering raven-black head, in which its eyes, and two fharp-pointed teeth are placed. The reft of the body is of a whitifh or flefhy colour. Six legs are fixed to the breaft, eight in the middle of the body; and two are fituated in the extremity of the abdomen under the tail. The Moth, however, never creeps out of its habitation, but by the fix fore feet; by the help of the other ten, it lies fixed in its little cafe: that is, when that Worm advances forward with its fix fore feet, then it takes hold of its cell within, with the others: and this too is the reafon, why it always carries its cafe with it, not differing much in this refpect from tortoifes.

But the Moth, while growing, always entirely forfakes its cafe, when it is become too little for its body, being on account of the increafe of bulk, obliged to form itfelf an intire new cell, into which, as into a new habitation, it afterwards repairs, after leaving the old one. The Moth never undertakes that office, until compelled by neceffity; that is, when the old habitation is not fufficient to cover its body. The inftinct and prudence of this creature, are moft evident from hence, that in preparing an habitation big enough for its body, it does not defire large and magnificent buildings, which the folly of mankind fo much feeks after. Man, whom God created with an upright countenance, over-burthens himfelf with heavy labour, nay, he fometimes perifhes under a multitude of houfes and apartments; the tapeftry and hangings of which are expofed to this Moth, only to be gnawed and eaten for food.

When the Moth leaves its former cafe, in order to form for itfelf an entire new cell, it does not get for that purpofe beams of cedar, nor Italian marble: it prudently and ingenioufly makes ufe of that matter which it finds near about it. When it lives in green cloth, it makes the outfide of its whole cell of a green matter; that is, the wool which it bites off the cloth, and artificially interweaves with its web: it lives on the fame fubftance, and ufes it for food; and therefore its excrements are alfo green. It does the fame when it refts or pitches on white, yellow, red, blue or black cloth; or when it finds in its way any coverlid, garment, or cap, that lies unufed and neglected in a corner. If it can find none of thefe materials, it remains in old old houfes, armories, repofitories, and even in ftone walls; it eats duft and Spiders-webs, whereof it makes an habitation in the fame manner. I have, on thefe occafions, feen it interweave fmall bits of broken cement with its habitation, in order to make it ftronger; fo that this creature makes every foil its country, and yielding to neceffity, leads a happy life amidft the miferies to which we are fubject.

The Moth never brings any foreign matter into the inner furface of its cell, where its body lies; confequently nothing elfe is obferved there, only the Moth's proper web, which being of a foft, fmooth, and even texture, ferves both for a habitation and bed. In this manner that Worm lives, till its parts are increafed to their due perfection under the fkin: and at that time, it covers both the orifices of its little cafe, and caft-ing of its old fkin within, Tab. XLV. Fig. XXXI. *e*, is changed into a Chryfalis, which is properly referred to the fecond mode of our third order; becaufe it does not very clearly exhibit the limbs of the infect to be produced from thence: this is a nocturnal Butterfly, or Moth. When this infect is firft changed, all its parts are beautifully white, but they afterwards grow infenfibly yellowifh, and at length acquire a faint red, which they finally preferve. In the head, particularly the eyes, which are feen through the fkin, firft acquire their colour and perfection; afterwards the whole body finally appears through the fkin, of the fame colour with the nocturnal Butterfly, to be produced from thence.

July 13th, the Butterfly appeared, *f*, after it had lain twelve or thirteen days under the form of a Chryfalis, without food or motion, and its tender limbs had, by the evaporation of the fuperfluous humours, infenfibly acquired fufficient ftrength to break open the outmoft fkin. This Butterfly was provided with four wings, fix legs, two horns, and two black eyes. Its wings and body had many fuperb fcaly feathers, which very beautifully adorned the creature with various and agreeable colours. Thefe colours being viewed with a naked eye, refemble fine flour, and may be eafily reduced to fuch a powder with the fingers: and therefore, frail man, as mentioned in fcripture, is very properly compared to a Moth.

This little creature, the Butterfly, is commonly called a Moth; though it is noxious on no other account, but that it lays thofe fpheroidal eggs out of which the real Moths, or eating Worms, are at length produced, in hangings and cloaths, in like manner as the Flies producing Maggots lay theirs in meat, fifh, cheefe, and meal. When thefe creatures fly or flutter about, thofe who would preferve treafure from Moths, muft be careful to keep them from it; for otherwife their neglect will be a great hurt to them, and caufe much lofs and concern. Thefe are the confequences that commonly attend floth and negligence.

When this Moth hath broken out of its woven cell, it is always obferved, Tab. XLV. Fig. XXXI. *g*, to hang a little out of one extremity of the fkin, which the Chryfalis had caft. But if the cafe itfelf be then opened, one may diftinctly fee how even and fmooth it is woven, *h*. I fhould never finifh, if I attempted to defcribe and delineate all the fpecies of Moths, fince there is a great number and variety of them. I fhould think, that what hath been hitherto faid is fufficient, fo that there is no need of more; for it is eafy to know a Lion by his paw.

Of certain Worms that, like the Moths, live in cells, feeding on the leaves of Pear-trees, Apple-trees, Plum-trees, and Cherry-trees.

OBSERVATION I.

I Preferve, in my collection, various and particular fpecies of thefe Worms, fome of which form their cells of bits of wood, which they bite off; and hence are properly called Ligni perdæ: but of thefe I fhall hereafter treat in another place. The firft fpecies of thofe, of which I am to treat here, was fhewn me on the leaf of a Cherry-tree, by the very experienced and celebrated Dr. Luke Schaght, profeffor of the Materia Medica in the univerfity of Leyden. I afterwards found it likewife on the leaves of the Willow and Alder-tree. The cell which this Worm inhabited was black as pitch, Fig. XXXIII. *a*; and confifted of a fubftance, as it were, of bark, and woven into wrinkles. Its hinder part was thicker than the fore part, and divided, as it were, into two lobes. Its foremoft extremity terminated fomewhat acutely, and out of it crept its inhabitant, carrying this little cafe entire, obliquely on its body; but when the Worm refted, the cafe ftood perpendicular on the leaf.

This Worm was, in regard to its ftructure, fcarce different from the Moth. When it has eat enough, it fixes itfelf to the leaf, near the opening of its cell, and is changed within it into a Nymph of the firft mode of our third order, which *b* grows at length into a very beautiful Fly. On the head of this Fly, which is black, are placed two redifh horns. Its thorax and abdomen are partly red, and partly black. It has four beautiful membranaceous wings, which fhine like very fine Mother of Pearl; and are likewife variegated, nearly in the middle, with two black fpots. It has moreover fix red legs, which are divided into joints, each having two claws at its extremity. This creature is alert and fprightly, and flies very fwift.

OBSERVATION II.

I Found a fecond fpecies of thofe Worms, which carry their cell with them, on the leaf of the Alder-tree. This creature fed on the inward coat of the leaf, and therefore confumed it all unto the nerves of that external coat. It does not differ much from the former, except in refpect of its habitation, which it carries every where on its body: but in this there is a confiderable difference; that is, it is of the colour of the leaves that fall in autumn, tho' fome of thefe cells are alfo found of a ftronger colour. This cell is triangular, Tab. XLV. Fig. XXXIV. *c*, at the upper extremity: it fwells a little in the middle; but the part that contains the body of the creature, is again contracted, and therefore it is formed like a big-bellied cylinder.

I have ſeen three ſorts of creatures produced from theſe Worms; for as one of theſe ſmall creatures had, according to the ſecond mode of the third order, been changed into a Nymph, which aſſumed the form of the future Butterfly, I at length obſerved a pretty little nocturnal Butterfly or Moth, not much different from the Cloaths-Moth, ſprung *d* out of it. I ſaw a black Fly *e* with two horns, four wings, and ſix legs, produced from another ſimilar Nymph, which however ſhewed before the form of a Fly, according to the firſt ſpecies of the third order. But the moſt ſingular event of all was, ſix or ſeven very ſmall *f* Flies, which, from more tender Worms, had been firſt transformed into Nymphs, iſſued out of another Chryſalis of ſuch a Vermicle as belonged to the ſecond mode of the third order. Whether this be common, and conſtantly happens annually, as is the caſe in other Caterpillars; or whether it be peculiar only to thoſe that inhabit the bright brown cells, in which only I obſerved it, I have not indeed yet learned from experience. And, indeed, what man can perfectly inveſtigate all the changes of parts which happen, even in one creature. I am, indeed, every moment taught by experience, that nature is, in regard to thoſe real cauſes, by which animals and their parts increaſe, in many particulars, perfectly impenetrable to man. However, a firm and conſtant diligence hath, by degrees, diſcovered to me more than one could eaſily believe; though what we are ignorant of is, and will remain, much greater than all we know. Hence, indeed, we have knowledge of many things; but our ignorance ſtill prevails and predominates.

Of certain Vermicles or Worms, whoſe eggs are lodged in the bags wherein muſk is brought to us.

I Should never make an end, if I attempted even to enumerate all the hidden changes of the Caterpillar and Worm kinds into winged inſects; ſo fruitful and manifold is Nature in her genera and ſpecies! For this reaſon I ſhall only add the following obſervation, and afterwards finiſh this hiſtory of the fourth order with accounts of two Worms which live in tubes, one in the earth, and the other in the water; for the water abounds as much with theſe inſects as the land.

On the 10th of July I found a great many ſmall white Worms, Tab. XLV. Fig. XXXII. in a bag, wherein muſk comes to us. All theſe had a reddiſh brown head, and black teeth. Six legs adhered to the breaſt. The body was covered with fine hairs, ſtanding erect. This muſk-bag was in a little box, not very cloſely ſhut, the bottom of which was covered with white paper, through which theſe Worms penetrated into the wood of the box, by various holes which they gnawed through it. And indeed thoſe holes, which are as conſpicuous in the paper as in the wood, moved the admiration of the perſons who viewed *b* them. As they were bit regularly into a round, oblong, or oval circumference. I further obſerved, that many of theſe Worms made themſelves in their caverns a pretty thick, oval, lemon-coloured web, whereon they had weaved many cotton-threads, after the bag of muſk had been placed in the cotton.

When I opened theſe webs, I found real Nymphs in them, Tab. XLV. Fig. XXXII. *d*, which belonged to the firſt mode of the third order; for each very diſtinctly repreſented the limbs of a future Beetle. Some of theſe Nymphs were very white; but in others, which were older, the eyes were turned black, and the whole Nymph, from white, inſenſibly became tinctured with various colours; and was, at length, changed *e* into a very beautiful little Beetle, after caſting its ſkin. When theſe Beetles have newly caſt their ſkin, in which they appear like Nymphs, they are of a ſnowy white colour: they afterwards grow yellow by degrees, till at laſt they become of a duſky purpliſh hue, and afterwards always continue ſo: ſome of them, however, conſtantly preſerved a colour between yellow and red.

They are diſtinctly divided into the head, thorax, and belly. They have two black eyes in the head, juſt over which project two rediſh horns, thick ſet with fine hairs of the ſame colour. The thorax is likewiſe adorned with yellowiſh hairs, that glitter almoſt like gold, and exhibit ſix hairy legs of the ſame colour with the horns, affixed to its lower region. The caſes or covers of the wings are divided with ribs; and the latter, together with ſeveral little depreſſions, are every where ſet, as it were, with fine hairs. This obtains chiefly about the ſhoulder-blades, and on the hinder part, where theſe caſes or covers are bent, near the extremity of the abdomen; for they have a tuft of whitiſh hairs in the fore and hindermoſt parts. The under wings are membranaceous, and they very expeditiouſly fold themſelves under the ſheaths or caſes with which they are covered, notwithſtanding their being twice the length of the abdomen.

This ſpecies of Beetles may, on account of the conſtruction of the horns, be referred to the flying Capricorn kind. I have ſeen Beetles produced from ſome other ſpecies of Worms, that live on rotten and hollow wood; the horns of which were formed in the ſame manner as the Silkworm Butterflies. The only difference was, that all their diviſions or plates were ſeverally jointed together. This ſtructure formed a very beautiful ſight, and clearly demonſtrated the wiſdom and art of the Creator. This is ſtill more evidently confpicuous in the Fullo-Beetle, whofe female is delineated in Mouffet; but it wants thofe ornaments, which are found in many fpecies of infects, peculiar to the males, wherein they are more beautiful than the females.

The Worms here defcribed feed on birds feathers, and therefore do a great deal of mifchief. They are found in feveral places in Holland, and may be reckoned among the fecond fpecies of Worms that gnaw flefh clean from bones; and therefore are very proper to prepare fine fkeletons.

Of certain Worms which lie in little tubes or cells.

OBSERVATION I.

I Preferve feveral fpecies of tubes in which Worms live *; but I fhall not, in this place, defcribe them all. The firft which I here exhibit is formed by a Worm, refembling a Caterpillar; which makes, Tab. XLV. Fig. xxxv. a pyramidal tube or pipe for itfelf, to which it afterwards faftens, for greater firmnefs, various little parts, bitten off from plants and leaves of trees; fo that the furface of the tube refembles thofe chequered works, with which the doors of armories and caftles were formerly adorned: and with this beautiful cell the Worm walks and goes about, till it is changed into a winged creature, being difengaged then from the burthen of its houfe and bed, which it was hitherto obliged to carry.

OBSERVATION II.

THE tube, whofe figure I here add, Fig. xxxvi. to the former, is not lefs beautiful or artificial in its ftructure. I found it in the falt water, on the coaft of the German fea. It is inhabited by a tender Worm without feet, having many gold-coloured briftly hairs in the fore part of its head; by the help of which it can gnaw innumerable grains of fand, and join them fo accurately together, that even the moft nice artifts muft be aftonifhed at it. The inner furface of this tubulated and pyramidal cylinder is fmooth and equal; but the external part is, on the contrary, uneven. This difference proceeds from hence, that the creature can turn all the plain and polifhed furfaces of the fand inward, and leave the angulated and rough furfaces on the outfide. The figure, by which I reprefent this tube, exhibits only the third part of its natural fize: it could not be all delineated otherwife, for want of room in the plate. I have not yet obferved what kind of metamorphofis this infect undergoes.

It merits great confideration, what kind of faliva or glutinous moifture that is, by which this Worm can faften the grains of fand together in fuch a manner, that the whole contexture dries and hardens in the falt water. I muft ingenuoufly confefs, I am doubtful in this as well as many other matters; fince I can by no means conceive how this piece of art is executed. I have obferved, that many other aquatic infects alfo frame a web or covering, under the water; the thread whereof hardens in the midft of the fluid, in the fame manner as the Silkworm-webs in the air.

In regard to the other aquatic infects, I have obferved, that fome of them form their cells of fmall fragments of ftones; others of larger pieces joined together; fome of fnail-fhells, which they have gathered up and faftened together; others again are made of pieces of rufhes, various parts of plants, wood, and other materials: nay, I have feen fome, which, when they were preparing for their change into tne winged ftate, could weave very heavy ftones into their cells, and fortify them, as it were, with a lattice-work of mafonry. They dived to the bottom of the water by this means, and, being there free from all danger, they changed and renewed their bodies. God is therefore admirable, wherever he is manifefted: he hath reprefented his omnipotence and wifdom in all his creatures; therefore, let him only be honoured and glorified to all eternity.

The End of the Hiftory of Infects that inhabit fruits, tubercles, leaves, and the like.

* The name by which this kind of infect is generally called, at this time, is Tinea Campeftris, the Field Moth. Reaumer, who gave them this name, obferves, that their origin and manner of life are the fame with thofe of the common Cloaths Moths; the only difference being, that thefe feed upon moift, the other upon dry food.

A par-

A particular treatise on the Frog and its young, exhibiting its history, and comparing it with insects.

TAB. XLVI.

A Comparifon of the metamorphofis, and, if I may be allowed the expreffion, a tranfcretion of the parts, happening in young Frogs, with that obferved in the Nymphs of infects.

As, in the preceding fheets, I have occafionally, though flightly, touched on the likenefs of the change of limbs in the larger or fanguiferous animals, to that which infects undergo; I fhall here delineate and explain this fubject more at large, in order to make the knowledge of it diftinct and clear. For this purpofe *,

Tab. XLVI. N°. I. exhibits the Frog's real egg, or the Worm of the young Frog, enclofed in its firft coat. It reprefents a fmall *a* black globule, furrounded *bb* by another globe, confifting of a clear, clammy, and glutinous matter. This matter is the real food of the Worm of the Frog, which now lies within, covered as yet with its proper integuments: therefore the Frog's Vermicle or Worm may be confidered as the yolk, and the food the white of this egg.

N°. II. I lightly exprefs the invefting coat or integument before mentioned. It is here caft off *c*, and rolled back *d* to the hinder part of the Frog. It likewife appears, in this figure, how much the furrounding aliment is now dilated, *eee*. Hence the young Frog is circumftanced exactly in the fame manner as all Worms and Caterpillars of each of the four orders are, when they have caft their firft coat, or their egg-fhell; in which I call them Oviform-Nymph-Animals, or Oviform-Nymph-Vermicles, as may be feen particularly in the fourth order, where the egg is confidered.

N°. III. It is delineated to the life how the young Frog, called a Tadpole by authors, fwims in the middle of its food, and alfo in what manner that food appears in the water like a difperfed cloud, *fff*. The Vermicle or Worm itfelf is here delineated much larger than it was, when it firft began to fwim into its food, immediately after quitting its fhell, or firft membranaceous integument. Therefore one may now very diftinctly fee its head, breaft, and body. But becaufe the perfon, who I fhall defire to diftinguifh thefe parts, ought to have a thorough knowledge of them, thofe who inveftigate nature but fuperficially, look into that globe only for the young Frog's head, though it really comprehends the whole body; as the incomparable Harvey has before juft obferved. At the extremity of this young Frog's body is feen a long continued tail, Tab. XLVI. N°. III. *h*, by the help of which it fwims; fince the Frog is, whilft it wears that form, a real footlefs Worm, and, in this refpect, refembles the feetlefs or apode Vermicles or Worms of the firft mode in our third order.

Here it muft be well obferved, that the young Frogs never confume their food entirely; which, for that reafon, is diluted by the imbibed fluid, and gradually attenuated; fo that, at laft, it refembles a little cloud floating in the water. Indeed, that gluy cloud is infenfibly dilated to fuch a degree, that it feems defigned for the young Frog as a place to reft in, when it fhall think proper: for which reafon it is likewife obferved, that, when tired with fwimming, it quickly penetrates into this cloud, and there remains without motion.

And here I fhall beg leave to obferve further, that as the infects which are found in cheefe, putrified flefh, and many fruits, and in tubercles, lie furrounded with their nourifhment; fo, in like manner, the young Frog fwallows its food, at this time, through its mouth, as they do. There is however this difference, that the young Frog is nourifhed while it yet lies in the integument or coat of its eggs; and this I could never obferve with refpect to any other infects. The infects, in general, lie in the coats of their eggs, in the fame manner as Butterflies do in their Caterpillars, and only increafe in ftrength. Therefore, I do not doubt but the young Frog is provided with umbilical veffels, of which matter I fhall afterwards treat in its place.

N°. IV. I reprefent how the hinder legs *ii* are obferved to increafe in the Tadpole, or young Frog; that is, whilft they infenfibly fpring out of the body, as the cups of flowers from out of their footftalks, or as the cafes wherein the wings of infects are at firft repofited: fo that the young Frog is, in this refpect, very like thofe little creatures defcribed under the fecond order; though it again differs from them, in that it is produced from the egg in form of a footlefs Worm.

I likewife obferve, that about this time the young Frog's fore legs are infenfibly increafed and augmented, under the fkin, in fuch manner as I have before explained, in regard to the Worms and Caterpillars of the third order. For this reafon one may likewife plainly diftinguifh, with the naked eye, the rudiments of the legs, if the fkin be then opened in that part. And this is likewife the cafe in all the Worms and Caterpillars juft mentioned, as I have occafionally exhibited in the former tables.

Tab. XLVI. N°. V. I here reprefent, to the life, how all the limbs of the young Frog have

* There is fcarce any animal which has the principle of life fo ftrong as the Frog. It will continue moving many hours after the guts are taken out. An Eel is celebrated for this ftrength of life; but the Frog exceeds it greatly. No creature is fo truly amphibious; for it will live for a length of time equally well on land without water, and abfolutely immerged in water. A Frog has been tied down under water many days, and received no hurt, nor fuffered any feeming inconvenience.

at length arrived to perfection, by a ſlow increaſe. The two fore feet are ſeen *k k* ſtill lying under the ſkin; but the two hinder legs project beyond the ſkin, *l l*, though they are, in reality, ſtill inveſted with the ſkin of the Tadpole, which they afterwards are to caſt off. This ſkin is dilated and ſtretched out with the growing feet, as is likewiſe the caſe in injects of the ſecond and third order. Hence it is, that I really very properly give the young Frog, in this form, the appellation of the Frog's Nymph, which it ſeems may be likewiſe referred to the ſecond or third order. But as the young Frog, while it is under this form of a Nymph, ſtill ſeeks its food, and moves about, it therefore approaches much nearer to the inſects of the ſecond order, than to thoſe of the third; for this reaſon, it likewiſe caſts its ſkin in moving and ſwimming, and brings to view its fore legs, then reſembling thoſe of a perfect Frog; though it ſtill, for a long time, keeps its tail, which afterwards ſhrivels up by degrees, and, finally, dries away.

N°. VI. I ſhow how the Frog, having gradually gone through the forms of an Egg, Worm, and Nymph, at length has attained its perfect maturity, and appears fit for propagating its ſpecies, in the ſame manner as inſects and vegetables, and thus is able to continue its generation. It muſt be obſerved here, that the Frog is not abſolutely perfect, or fit for generation, immediately after its metamorphoſis. By no means; for, unleſs I am greatly miſtaken, this creature does not acquire that degree of perfection until two or three years. The Frog, therefore, differs in this double reſpect from the ſanguiferous animals, and from inſects; moſt of which are perfect in one or two hours after their birth, or after their metamorphoſis from Nymphs, and then likewiſe immediately obtain their full ſize and maturity, and at the ſame time become fit for the office of generation. The Frog which I here expreſs, of full age, is the male; as one may very certainly know from thoſe two veſicles, Tab. XLVI. N°. VI. *mm*, which are ſituated behind its eyes, and are never to be found in the female. There is moreover another certain ſign, whereby the male may be diſtinguiſhed from the female; but that I ſhall deſcribe and delineate in a particular hiſtory, which I ſhall ſubjoin to this general account.

Man himſelf compared with inſects, and with the Frog.

IT is evident from comparing the Frogs, as we have juſt now done, with the inſect tribe, how the ſanguiferous animals, or ſuch as have red blood in their veſſels, are, in repect to their changes, like theſe ſmaller creatures. Indeed this likeneſs proceeds ſo far, that it extends under many names, even to man himſelf: for all the works of God ſeem to proclaim, only one foundation of propagation and increaſe.

I firſt obſerve, that it is clearer than the light at noon, that man is, like inſects, produced from a viſible egg, which, after being impregnated, is brought forth: that is, it is by a local motion conveyed out of the ovary through a tube into the uterus, which is the place wherein man, that rational animal, finds his firſt nouriſhment, and repreſents, as it were, a Vermicle or Worm, or, to uſe Harvey's words, a Maggot lying in the egg.

Secondly, The membranes which then inveſt the Infant-Man, are there likewiſe dilated, in order to receive an aqueous humour conveyed from without to the Man-Vermicle. Therefore, the human egg likewiſe reſembles the eggs of inſects, in that the latter dilate, nay, break open their coats, in order to get elſewhere the nouriſhment which they do not find in their egg.

Thirdly, We obſerve, that the Vermicle or Maggot of Man, as well as the Vermicles or Worms of other inſects, have not completely perfect limbs; therefore it is increaſed in ſize, even from the beginning, till its limbs project at length out of the ſkin, and its umbilical cord is divided into two arteries and one vein, which take root in the internal ſurface of the uterus, and conſtitute the placenta, or after-birth.

Fourthly, It is very clearly obſerved, that theſe parts of the Man-Vermicle grow by degrees into a head, thorax, belly, and limbs. In the head, the coloured eyes are very diſtinctly ſeen through the ſkin; but they are more conſpicuous in the beginning than afterwards, when the ſkin becomes thicker; for then they can be no longer ſeen. But it is indeed very admirable to obſerve, how the limbs ſprout about the ſhoulder-blades, and at the lower parts of the body: for, in the beginning, they reſemble the ſmall cups of flowers juſt budding, or the bags and caſes of the parts of inſects; the former encloſing the flowers, and the latter the wings; and then, by degrees, juſt as the legs of Frogs, they grow out of the body, and are divided into joints.

Fifthly, We obſerve further, that all the limbs of the Man-Vermicle, in time, acquire their due perfection, and are ſtrengthened to ſuch a degree, as to be able to break out of the uterus, and to diſengage themſelves from all their integuments. And hence this firſt ſtate of man likewiſe reſembles an inſect, in that it hath, under the form of a Chryſalis or Nymph, acquired all the ſtrength requiſite to change its skin, and appear like a perfect creature. Man therefore, as on the point of his birth he does, like inſects, throw off and loſe ſeveral very conſiderable parts, may indeed be deſervedly called, at that time, a Nymph; ſince he then is to caſt off his umbelical veſſels and placenta, together with the skin and the amnion.

Sixthly, This tender and new-born creature leaves the uterus, in the ſame manner as the Ephemerus and Libella, that have caſt their skin, and leads a new life, and has a different nouriſhment.

ment. The infant-man, who lived before in the water of the amnion, now breathes the vital air, which ruſhes into his lungs, and dilates and extends them. But this miſerable creature is very far from meeting with ſuch good fortune, as the Ephemerus and Libella, which are in an inſtant brought forth abſolutely perfect. On the other hand, his appendage of misfortunes and trouble, like the tail of the Frog, yet adheres for a long time to him, for he is full of miſery, and is born in tears; and it is very long before he comes to maturity of underſtanding, and full growth of body. It is now time to come to the ſingular hiſtory of the Frog; which is highly worthy of conſideration.

A particular treatiſe on the generation of Frogs.

HAVING hitherto premiſed only general obſervations, and ſuch as tended to explain the figures in Tab. XLVI. I ſhall here treat particularly of the generation of Frogs, and deſcribe the genital parts of the male and female, and ſhall add ſome other obſervations, I hope, of ſome uſe. I would, on firſt ſetting out, inform the reader, that there is a much greater number of miracles, and natural ſecrets in the Frog, than any one hath ever before thought of or diſcovered; as I ſhall evidently demonſtrate, when I ſhall have opportunities to deſcribe particularly the whole hiſtory of that animal; and I am now here to explain a great part of it.

The genital organs of the male are the teſticles, the vaſa deferentia and ſeminal veſicles. The teſticles, Tab. XLVII. Fig. 1. *a a* are placed in the loins, and being there ſituated over the kidneys themſelves, *b b b b*, are furniſhed with arteries, veins, and ſpermatic veſſels. Their figure is not conſtantly the ſame, but is ſometimes obſerved to be more oblong, ſometimes more round, and ſometimes lunated. Some yellow appendages always adhere *c* to the upper part of the teſticles; and theſe appendages are ſometimes ſingle, *d*, ſometimes double, *e*, and at other times triple or quadruple. Theſe little parts likewiſe have their blood veſſels, and conſiſt of ſeveral bags joined together, and containing an oily or fatty matter; and encloſed in ſo many oblong common membranes, produced like appendages. I have likewiſe ſometimes obſerved, that this oily matter was joined to the coat inveſting the teſticles, and diffuſed through half their ſurface. A kind of ſimilar, but white fatty matter, is obſerved in Rats, and ſeveral other animals.

Theſe appendages may be examined with great eaſe in Frogs, that are not bigger than the firſt joint of one's thumb; for, by the help of a microſcope, we then diſtinctly perceive, that they conſiſt of a congeries of minute ſpherical and membranaceous particles, full of a yellow, oily, or fatty ſubſtance; but theſe particles are too ſmall to come under the cognizance of the naked eye, to which they only appear as a bright heap of tranſparent gold duſt.

The teſticles are generally yellow, with many blood veſſels elegantly variegated with black, beautifully running through the coats that inveſt them, Tab. XLVII. Fig. 1. *f*. On ſtripping this coat from off the teſticles, they appear to conſiſt entirely, as it were, of ſmall globules, *g g*, but by making this ſeparation ſlowly, and by careful degrees, we may clearly perceive, that theſe apparent globules are no other than the heads of ſo many ſeminal ducts; ſome of them double, *h*, or divided into branches, that riſe all to the center of the teſticle. In Frogs, therefore, the teſticles is compoſed of ſeminal veſſels; and I have diſcovered the ſame to be the caſe in many other animals, as the cuts I have occaſionally given demonſtrate.

Some pretty conſiderable ſeminal veſſels, *i i*, riſe from the internal ſide of the teſticles; part of them ſingle, and part divided into branches, which convey the ſperm, as it were, by ſo many different ſtreams from the teſticles: this may be eaſily ſeen, on compreſſing or ſqueezing theſe laſt parts ever ſo little; for then the ſeminal veſſels, firſt mentioned, fill with a pale white ſperm. Theſe ſeminal veſſels, or natural diviſions of the paraſtata, run by degrees towards the kidneys, upon which the teſticles lie, and, after paſſing through the coats of the kidneys themſelves, and forming a variety of diviſions, *k k*, they at length diſcharge themſelves into the vaſa deferentia, which are ſeated near the internal edge of the kidneys, *l l l*, and are there united with the ſeminal veſſels already taken notice of.

We muſt here duly obſerve, that the kidneys diſcharge their urine by the vaſa deferentia, thro' which the teſticles, in copulation, eject their ſperm: as in man, the ſperm and urine are diſcharged through the ſame urethra. In man, indeed, there is but a ſingle vas deferens, diſtinct from the ureters; nor has this urine any ſuch paſſage; whereas, in Frogs, the great Architect has thought proper to make the ſame veſſel ſerve both theſe purpoſes; and this, perhaps, he ordained, becauſe it was proper to contract or abridge the number of parts that were to be placed in ſo ſmall a body, and likewiſe becauſe the Frog was to evacuate its ſperm only once a year *.

In the midſt, between the two kidneys, are to be ſeen the arteries, and emulgent or kidney veins, Tab. XLVII. Fig. 1. *m m*; theſe I have but rudely deſigned. They are diſtributed all over the ſurface, and through the ſubſtance of the kidneys, by ſo many ramifications, that great circumſpection is neceſſary, not to confound the ſeminal veſſels, juſt deſcribed, with theſe blood veſſels.

* The animalcules in ſemine, are ſeen more eaſily and diſtinctly in the ſperm of the male Frog, than any other way. They who doubt the exiſtence of ſuch animalcules, (for it is at preſent a faſhion to doubt them) have not examined the male ſperm of this creature. The proper ſeaſon in England is the firſt week in April. The veſſels are then full of the fluid, and theſe animals are innumerable in it.

vessels. Beneath the testicles, and under the skin of the kidneys, there lie two other singular, and strange bodies, *n n*, but I neglected duly examining them.

The vas deferens grows smaller by degrees, so as to form but one trunk, *o o*, but soon again it dilates considerably, and in this part we may distinctly see the seminal vesicles lying against it, *p p*. These vesicles do not differ in construction from the correspondent vessels in man, and other animals, except in regard to their being of a more membranaceous substance. They open into the vasa deferentia, and convey to them from a great many little cells, an aqueous seminal fluid, which is perhaps the vehicle of the true sperm. In fine, both these vesicles, and the vasa deferentia are inserted into the surface of the rectum, *q q*, directly under the bottom of the urinary bladder, where I have represented both their mouths, by two openings *r* that appear through the straight gut. Upon this last intestine lies a double urinary bladder, *s s*, into which the urine is conveyed by those ureters, which at the same time perform the office of the vasa deferentia. When first I discovered these vasa deferentia, I immediately searched for the ureters, with a great deal of attention, as I could hardly think, that a vessel of such importance could serve two such different purposes. But I afterwards found, that the ureters of the female Frog, were constructed in the same manner as these vesicles in the male; and by this discovery, I became thoroughly acquainted with all these parts. I have accordingly exhibit them, as they appeared in the smaller Frogs, as may be seen by inspecting the second figure.

It is now time to say something of the genital parts of the female: these are an ovary, uterine tubes, or horns of the uterus, and the uterus itself. The ovary lies upon the uterus, with which it is always united; and near the same place are the fatty appendages, which I described in the male Frog, when I treated of the genital parts. The ovary, which is always double, equally occupies the right and left region, and is constantly found subdivided into lobules. I have seen them, to the number of five, on a side in some Frogs. Nature, however, does not always observe the same order in this particular, except that the ovary never appears, but divided into more or less of these parts. The blood vessels are principally distributed through these divisions of the ovary, Tab. XLVII. Fig. III. *a*, and afterwards they diffuse themselves all over it. Each lobule is hollow, and wrapped up in its own particular coat; so that, by fixing in a little tube, *f*, it may be easily distended with air, and separated from the neighbouring lobules, *b*. This must be done very cautiously, because this coat is so tender, that any thing of a rough blast would burst it. We may then plainly perceive, that all these lobules are confined, each to its own limits, and have not the least communication one with another.

As the coats investing the lobules of the ovary are so very delicate, the eggs may be seen thro' them distinctly, *c c*: a person that was not very cautious, by directing his eyes and hands to this part, might easily fancy to himself, that the eggs lay on the outside of the ovary. These eggs are black, and perfectly round, and generally they have a white or yellow spot in the centre. They lie close to the internal surface of the coats or membranes that constitute the lobules of the ovary, and are fixed there by the blood vessels, as it were, by so many short little stalks. This circumstance is very visible, in cutting off one or two of the lobules of the ovary, *d*, for then the enclosed eggs shew themselves most distinctly.

But this experiment cannot be conveniently made, unless about the beginning of March, or a little afterwards, as it is chiefly at that season, that the ovaries abound with perfect eggs: this is moreover the properest time for examining the genital organs. On examining carefully the ovary at this period, we may likewise find in it a species of eggs different from those I have now described. These are smaller, white at first, and when pretty well grown, yellowish. These last eggs, however, are only the rudiments, not yet perfected; and therefore, they remain in the ovary, after it has disburthened itself of all the perfect eggs. But before I treat of this operation, I think proper to describe the uterine tubes or horns.

In Frogs, these tubes arise very high in the breast, from whence they stretch in the middle, from one end of the abdomen to the other, and terminate in the uterus, with which they lie concealed in the lower part of the belly, but so as to be able to move higher, according as the uterus dilates or contracts itself. Every Frog has two such tubes, which are placed, one at one side of its body, and the other at the other side.

Properly speaking, the superior part of the tube lies near the heart, and is connected on each side by the ligament, by which the liver also is suspended. In the same place, where part of the peritoneum passing freely over the heart and pericardium, forms with the liver a distinct cavity, in which the heart, wrapped up in its pericardium, lies under the breast bone, as in the hollow of the mediastinum or diaphragm. To see all these particulars distinctly, it is necessary to lay open the Frog's belly a little higher than the extremity of the breast-bone, where this bone degenerates into a cartilage; then cut off the membranaceous parts; and lastly, turn over the breast-bone upon the head, and secure it in that posture with a pin, Tab. XLVII. Fig. IV. *a*. Thus we discover a considerable cavity above and about the point of the heart, *b*, in which the heart lies hid with its pericardium, under the breast-bone, as within the diaphragm. At the same time, we may see on each side of the heart, the extreme ends or natural openings of the tubes, *c c*, which most firmly and immoveably grow there to the peritoneum, and to the ligament, by which the liver is suspended, so that they cannot reach to the ovary, which lies at too great a distance from them. Besides, these tubes are very slender and delicate. They bend a little, especially where they lie upon the lungs; for they stretch over the lungs and the liver, where they arise from very slender membranaceous beginnings. For this reason, they

always

always are ready to collapfe, and are only difcernible by thofe who have accuftomed their eyes to fuch inquiries by frequent diffections. Such perfons can readily demonftrate, or produce them, even without blowing them up.

The remainders of the tubes are moft elegantly curled, and folded up, as it were, in a great many wonderful plaits, *d d*. And indeed, the fhortnefs of the animal's body could not admit of any other conftruction, thefe tubes being fo very long, that, on meafuring a fingle one, feated on one fide of the body, I found it to be upwards of two feet. All thefe beautiful foldings and windings of thefe tubes, are connected by means of a flight membrane, through which there run a great number of blood veffels, *e*, in a very orderly manner.

The extremities of thefe tubes open by wide mouths, *f f*, into the two fides of the uterus. Thefe mouths appear circular when diffected, after they they have been inflated and dried; but they are oval when the parts are any ways moift, as they then collapfe. The uterus itfelf is double, *g g*: it is of a membranaceous fubftance, and is elegantly overfpread with blood veffels. When full of eggs, it wants very little of being fpherical in fhape; but when inflated, it is rather oblong, and fhaped like a pear: the introduced air gives it a fomewhat different figure. Finally, the uterus terminates at each fide of the body, in the rectum, about half an inch from the place where the tubes are inferted into the uterus. In all Frogs, the ftraight gut *h* is placed between the right and left portions of the uterus, and fhews on its forepart the bladder, which is likewife double in this place, *i*. I have here mentioned nothing, that I have not diftinguifhed with my own fenfes in a Frog, which had difcharged its eggs, about half an hour before I diffected it.

The fame figure likewife reprefents the contracted ovary belonging to the left fide, *k*, feated at a great diftance from the mouth of the tube, with one imperfect egg, which had not as yet difengaged itfelf, but remained entangled with the ovary. One of the kidneys likewife may be here in part feen, *l*, together with the pinguiferous appendages of the ovary, *m*. I alfo exhibit two eggs which I found loofe in the abdomen, *n*, on account of their ftraying from the mouth of the tube, in the act of copulation. The tube itfelf alfo ftill contained another egg, *o*, fallen into it, after all the others had been conveyed into the uterus. This was very plain from this egg's not as yet having any white. The ftomach, *p*, and alfo the fmall guts appear in their natural fituation; and a portion of the liver, *q*, and fome of the fineft blood veffels, are diftributed over the furface of the ftomach. On the fide of the liver, I reprefent the gall bladder, *r*, and the lungs with their veffels, *s s*. I made an incifion into one of the parts, to let the air in it efcape, that I might the more clearly exhibit the courfe and opening of the tube; the other, on the contrary, being the right, I exhibit as it appeared diftended with air. The auricle of the heart is reprefented, *t t*, divided by a membrane not unlike a valve; it is tranfparent. I next fhew, in the fame place, the feparated parts of the abdomen and breaft, *u u u*, interfperfed with fome mufcles, having endeavoured as much as poffible to fhew all thefe parts in one and the fame figure, and of their natural bignefs.

Here I cannot omit the opportunity of illuftrating the account of Oligerus Jacobæus, who owns he could not difcover the opening of the tube, and of fhewing him at the fame time how much he was miftaken in thinking, that the tube was inferted into the ftraight gut, which he has reprefented in an imperfect drawing. I fhall tranfcribe his words, efpecially as he has thought proper to charge me with the error which himfelf committed, a proceeding to which he was perhaps prompted, by the flatteries beftowed on him by the younger Bartholin, who extols, in the moft difguftful manner, this author, and his treatife on Frogs. But his panegerick ferves only to prove, that he underftands nothing of the moft curious branches of anatomy; otherwife he would be more cautious, not to cenfure in fo fupercilious and dictatorial a manner, performances which he has not fufficient abilities to underftand. For this reafon alfo, he appears a great deal more folicitous about the external appearance, than about the real nature of the fubjects he takes in hand. This may evidently appear by his treatife on the diaphragm, in which he has been at more pains to exprefs neatly, his own face and hair, than to make the figures of the things he treats of plain and intelligible, as if the learned were in love with his countenance.

The words of the illuftrious Jacobæus, in his obfervations upon Frogs, are as follow: "This tube, in the upper part, hides itfelf in the region of the heart, liver, and lungs; but where it afterwards ftretches its courfe, I cannot tell, as I could not get the air I ejected for that purpofe, to afcend any higher than this part. Below, where it runs under the ovary, it dilates into a pretty wide oval mouth, and branches into fibres that unite with the kidneys and ovary, whilft the reft of it is inferted into the ftraight gut, about a thumb's breadth from the oval mouth juft now mentioned." He afterwards adds, "Swammerdam, though very clear fighted upon every other occafion, does not feem to have taken notice of this oval mouth, when in his treatife on the conftruction of the womb in women, he fays, that in Frogs, the motion of the egg from the ovary, to the tubes and arteries, is more obfcure, as he tells us, the orifice of the horns of the uterus, or of the tubes, are about two fingers breadth diftant from the ovary, and that not only their orifice is very narrow, but the part alfo is unmoveable; and further, he denies that it lies clofe to the ovary, as in the females of the human and feathered fpecies."

We may reafonably imagine, this learned author did not fo much as think of any part of the uterus; for he does not, in his whole treatife, make the leaft mention of that part, and affirms, that the tube is inferted into the ftraight gut; whereas, on the contrary, it is the uterus itfelf that is inferted into that inteftine, and by no means

means the tube. Besides, the ovary of Frogs is never found to have naturally that figure, which Jacobæus very rashly gives it, though it is to be observed, that the uterus, when loaded with eggs, is found on dissection to have, in some degree, such an appearance. Therefore, the oval ostium, or mouth, which this author mentions, is, in my account, really the opening of the tube into the uterus, which, properly speaking, shews itself where the tube ends, and the uterus commences. See Tab. XLVII. Fig. IV. letters *ff*, where I have at large described all these parts.

Such being exactly the case, and it being at the same time certain, that the inferior extremity of the tube has no communication with the ovary; and that no eggs can enter there from the lobules of the ovary, which are perfectly closed; and as likewise M. Jacobæus could not discover the upper orifices of the tubes, I would be glad to know in what manner this author can explain the passage of the eggs from the ovary, into and through the tube. I really cannot conceive how he can acquit himself of this task; so that he has in good earnest made the motion of the egg, from the ovary more obscure, than he is pleased to fancy I had done. But I, by no means intend to enter the lists with this gentleman, or imprudently treat him with rough language; for it is not in search of glory to ourselves, but the great Creator, that we ought to survey and examine his works. For this reason, I rather look upon myself as under an obligation to this illustrious naturalist, for having condescended to criticise, and bring to the test my experiments concerning Frogs; and, in the same spirit, I must tell him, that he can never miss finding the opening of the tubes near the heart, provided he looks for it a little after the Frogs have deposited their eggs. At this time, even the whole uterus may be distended with air through the tube; and, on the other hand, from below, upwards, the tube thro' the uterus. What is still more, these openings of the tubes may be then discovered without any dissections, by only blowing slightly through a pipe in the adjoining part of the heart. But none of these experiments will succeed, whilst the eggs are only in their passage through the tube, at which time, perhaps Jacobæus surveyed these parts. Thus the natural opening of the tube becomes very discernible to those who take a right method to discover it. But is it not surprising, that the description given by me, and which Jacobæus must have seen, as he quotes it, did not open his eyes; for, though short, it is very plain and intelligible. Mankind is liable to error; but, to persist in it, after friendly admonition, shews a perverse arrogance, that will not submit to acknowledge its mistakes.

It is now time to speak of the egg's passage through the tube, from the ovary into the uterus, which is indeed not only difficult to express in words, but even to conceive, so that in the whole science of anatomy, equally abstruse and mysterious, I must own, that this is very obscure in many other animals, but in Frogs, it is altogether incomprehensible; for the ovary, as I remarked above, and am ready to demonstrate in the Frog itself, does not in any way communicate either with the tube or with the uterus. The opening of the tube cannot by any means move itself towards the ovary. Besides, there are no other mouths at which the eggs can be received, than the narrow membranaceous orifices of the tubes, which above grow to the membranes of the heart; so that there does not appear in this place the least trace of any oval mouth, by which it is said, that the tube opens itself about the inferior region of the ovary; for it is very easy to separate the tube and ovary from one another: and the ovary afterwards extracted from the body, may by itself be distended with air, and dried, not having the least aperture to let the air escape, or the least mark of ever having had one.

I have sometimes distinctly observed in breeding Frogs, that whereas the ovary of one that I dissected, about the beginning of April, still contained all its eggs; that of another, opened a few days afterwards, had lost the greatest part of them, Tab. XLVII. Fig. V. *a*. I could likewise, at the same time, easily discover a great many of the eggs that had escaped out of the uterus, and were broken, lying here and there in the abdomen *bbb*, between the lungs, and under the sinuses of the stomach and intestines, among the membranaceous parts of the viscera, and elsewhere. Some also appeared near the opening of the tubes *c*. Others were still adhering to its inside *ddd*, part in its higher, and part in its lower region. I even discovered an egg lying at the very mouth of the tube *e*, and in what manner the eggs were leisurely forced thro' the extremity of the tube into the uterus *ff*. I observed also, that the greatest part of the eggs still adhered to the uterus; which I here represent two ways. First, I exhibit the uterus as it naturally appears *g*, with the contained eggs visible thro' it, but very faintly; and on the other side I represent it as it looks, after having been macerated in water, or on its beginning to dry, after being exposed to the open air for some time; in both which cases it very distinctly shews the eggs shut up in its cavity *h*. I represent besides, lower down, the extremity of the double uterus *i*, which is inserted into the straight gut, about half an inch from the opening of the tubes into the uterus. Near the heart appears the beginning of the great artery, with two smaller arteries springing from it *k*. On each side, near the heart, are openings of the tubes *ll*; and I have represented the lungs as bearing upon these openings *mm*, in order to render their situation next above the lungs more distinctly perceivable. It is very remarkable, that living Worms are almost always found in the lungs of Frogs; I have often met with six in one Frog.*

* Naturalists have been perplexed extremely to account for the Worms found in the intestines; but these are much more strangely situated. They cannot have been swallowed in food by the Frog, for this would not be their place. The opinion of Vallisnieri is, that the Worms found in our intestines, were created with the human frame; and that the bowels are their natural and proper place of living: it is much more strongly probable here.

The

These Worms are, on their fore part, pretty like Lumbrici terrestres, or common Earth-worms, but on their hinder part they are somewhat thicker, and they generally lie in plaits and folds within the lungs. In size they differ but little from the Worm that gnaws or corrodes the shell of the common Wilk. Their colour is a yellowish white, except that they are black towards the tail, which variety in colour proceeds from that of the food they have taken into their bodies. They have their mouths constantly fixed to the internal membranes of the lungs, from which they suck the blood. On separating them cautiously from these membranes, we may discover in the membranes a little opening made by these insects, and even a small quantity of blood discharged from that aperture: the mouth also of the piratical Worm appears bloody, if immediately inspected. These Worms appear to have another aperture in their breast, which however I did not sufficiently examine. I omitted also taking a survey of their inside, except that I observed some great and small guts, and some distinct particles; but the insect's skin being transparent, these particulars could be seen without dissection.

Other kinds of Worms are often found also in the lungs of Frogs. These are like bristles, with sharp heads and tails, and they coil themselves up. In colour they differ little from the first kind, only that on the inside of their bodies they shew thro' their transparent skins, some of their intestines in the form of a little thread or line of a dusky brown. On opening both these species of Worms, immediately taken from the Frog, I found in them a great number of small particles wrapped up in an oblong membrane. On observing that these particles were not only all of the same size, but were likewise regularly placed as in an oviduct, my curiosity led me to examine them with a microscope, by which I at length convinced myself that this prodigious number of particles was no other than so many roundish, or oblong eggs, in which also there was a very discernible motion. This induced me to open some of them. But how great was my surprise on finding, that every egg contained a minute but perfect Worm lying folded up in it, like a young serpent in its egg! Even these little Worms, when extracted from their eggs, moved themselves exactly in the same manner with the parent-insect. This was an undeniable proof, that this Worm was both oviparous and viviparous; thus propagating its species in the most surprising manner. But I return to my proper task; for this little animal, tho' no longer than a young Frog ten days old, contained too many miracles to be published in a few pages.

To return therefore to the Frog itself, what I have said sufficiently shews, how the eggs are dispersed, when they break the ovary, and from thence roll into the cavity of the abdomen. But I would fain know, by what art, regular motion, or contrivance an egg lying thus loosely in the body, can be conveyed into a narrow tube, whose opening is placed very high up near the heart? Certainly, the best thing we can do on this occasion, is to own such a conveyance utterly inconceivable by human understanding, and humbly to acknowledge the narrow limits of our faculties. It cannot be denied, that at this time, the ovary is distended very much towards the upper parts of the belly, by the great size and number of the eggs it contains; nevertheless, the eggs which possess the lower part of the ovary, never lie nearer than within two fingers breadth from the opening of the tube; and in the largest Frogs, they are at a greater distance. Let us suppose them ever so near the tube, who will tell us how they can get into the opening of it, which some of the best anatomists could not discover. The eggs have no motion of their own; nor are there any muscles in the way to move them. I therefore conclude, that this motion of the eggs of Frogs lies hid in a mysterious darkness, too thick for human understanding to penetrate.

But however incomprehensible this motion may be, we may derive from it great light into the motion of the eggs in women, in whom this tube is moveable; so that it can apply its mouth to the ovary, in order to receive the egg falling from this last part, a thing which that industrious anatomist Bidloo saw, and procured a drawing of. I have myself observed more than fifty times in Frogs, that the eggs which had broken loose from the lobules of the ovary, had insinuated themselves into the tube, and thro' the tube into the uterus; nor do I see any manner of difficulty in conceiving how in any animals the egg once got into the tube, should from thence pass to the uterus, the difficulty entirely lies in the passage of the egg from the ovary to the tube. In the Frog there is all the reason in the world to call this motion a miracle; indeed, there is nothing to hinder us from giving it the same appellation in all other animals. The causes of wonder are the same in all; and in general, the motions of eggs serve most manifestly to prove, that the human understanding is confined within very narrow bounds.

I have sometimes counted upwards of eleven hundred eggs in one Frog, all which are to pass thro' the narrow, immoveable mouths of these two tubes; nor can such passage be looked upon as an easy matter, as these tubes scarce deserve to be considered as simple channels, but rather as the horns of the uterus, which other animals exhibit. The white of the egg is formed in them, to surround the Frog's egg, or fœtus, and afford the young animal nourishment for some days in the same manner as the colliquamentum, or white, does the Chicken. On this account also, it is impossible to distend these tubes with air at this time; it is even a difficult matter to alter, even by squeezing with the fingers, the situation of the eggs at that time fastened within the tubes, the matter supplied by them, for the nourishment of the Frog's fœtus, which it most regularly

larly ſurrounds, being very clammy and glutinous. For this reaſon the eggs do not paſs faſt, or eaſy thro' the tubes, but very leiſurely, and by ſlow degrees, and chiefly by the action of the muſcular fibres adminiſtring to the tubes, which little by little puſh the egg and its nouriſhment into the uterus.

I find this white of eggs to be a very nouriſhing ſubſtance; for which reaſon, when I had young Frogs to rear, I uſed, as often as I wanted, other food that was proper for them, to take a tube from the body of a female Frog, and give it to them cut into pieces, which they immediately faſtened upon, ſucking eagerly the juices that flowed from thence. This matter even diſſolves, and diffuſes itſelf in water, like the white of the Frog's egg, being of a ſimilar compoſition and ſubſtance: hence the tube itſelf, on being juſt thrown into water, becomes by degrees eight times as thick as before: but this experiment muſt be made within a few weeks of the eggs paſſing thro' the tubes, as afterwards they contain no more of the white or albumen.

This tube, no doubt, is furniſhed with its glands; tho' as yet I have not had the ſatisfaction of ſeeing them diſtinctly. I obſerved, however, that the tube on its inſide is thoroughly lined with a regular reticulated glandulous coat; from whoſe pores the albumen, or white is ſecreted. Behold what, and how many wonders appear in the Frog only! But we ought not to content ourſelves with a ſingle experiment; we ought to try every thing that appears, and in every manner in which it can be tried, to acquire a perfect knowledge of any thing we deſire to be thoroughly acquainted with.

It is no eaſy matter to determine whether the uterus contributes alſo to the generation of the white of the egg, and the full perfection of the egg itſelf, or only ſerves to collect all the eggs, and eject them at one and the ſame time. To me it appears probable, that the uterus ſerves merely as a receptacle for the eggs. It differs greatly from the tubes, as it is membranaceous, and in part fibrous, or compoſed of, or furniſhed with many fibres; but it is no ways glandular, for which reaſon it is always found in a contracted ſtate, and never exhibits itſelf diſtinctly, but when naturally diſtended with eggs, blown up with air, or injected with ſome kind of liquid. It is even impoſſible to diſtend it by macerating it in water; ſo that upon the whole, no two things can be more different than the tube and the uterus.

The eggs, as I ſaid before, at the time that the Frog is to diſcharge them, break looſe from the lobules of the ovary, to the inſides of which they adhered, and are forced by I know not what motion thro' the cavity of the abdomen into the open mouths of the tubes; but I cannot exactly determine how much time may be requiſite for this paſſage, as the Frog is very far from being tranſparent like ſome other animals. It may not, perhaps, be impoſſible to obſerve this proceſs in ſome other ſpecies: nevertheleſs, the knowledge of this truth could then be only analogically obtained.

About the ſame time we find that the teſticles and ſpermatic veſſels in the male Frog fill with ſperm. Theſe animals become then ſo eagerly intent on the buſineſs of propagation, that they take no care in a manner of their own ſafety; ſo that they may be eaſily caught with the hand. I believe that they eat nothing, or very little, during this fit of luſt, which laſts more or leſs time, according to the heat of the weather.

To carry on the intercourſe of the ſexes, which this great work requires, the male Frog leaps upon the female, and when ſeated on her back, he faſtens himſelf to her very firmly. For this reaſon, the Dutch country boors, with great propriety, tho' in their vulgar way, call this manner of copulation, the riding ſeaſon of the Frogs, as the male is carried about, riding, as it were, by the female.

It is neceſſary, thoſe who intend to diſſect this inſect, ſhould know how to diſtinguiſh the male from the female. I have obſerved two marks by which this diſtinction may be made. In the firſt place, the male has two air bladders, which he expands in croaking; and the mouths of theſe bladders are ſeated on the ſides of his jaws. Theſe bladders conſiſt of two membranes, which may be eaſily parted, and ſeparately diſtended with air, and ſo preſerved. One of theſe membranes is a continuation of the external ſkin; the other a continuation of the membrane of the palate; and this laſt is furniſhed with blood veſſels and muſcular fibres, which ſerve to contract and dilate theſe bladders. Properly ſpeaking, the orifices of theſe bladders lie in the upper region of the mouth, where the gums are ſeated in men; and near them, within the mouth likewiſe, are to be ſeen the orifices of the organs of hearing, or of the animals ears. The tympanum, or drum of the ear, lies withoutſide, immediately under the ſkin. The ſame conſtruction obtains alſo in the Chameleon.

The other mark of the male Frog is furniſhed by the animal's thumb, which is very thick in the males, Tab. XLVII. Fig. VI. *a.* perfectly black in ſome kinds, and covered with a great number of papillæ, *b*, which are likewiſe of an extreme blackneſs, and conſtructed in the ſame manner with the papillæ on the tongues of oxen. Theſe papillæ become rough in drying, and, like the rough ſkin called ſhagreen, feel very ruggid; their uſe I ſhall preſently deſcribe.

The males, at the time of copulation, leap on the females, and they continue ſometimes on their backs, for forty days ſucceſſively, according as the ſeaſon of the year is more or leſs cold, and the eggs take up more or leſs time in their paſſage to the organ that is to ſhed them. Sometimes theſe animals continue together in this manner even for a much longer time; as when the female is weak or ſickly, and the eggs on that account deſcend more ſlowly through the tubes to the uterus, or when they meet with delays in the abdomen or uterus, as I obſerved in ſome Frogs, whoſe intercourſe laſted a very long time.

The very moment the female has depofited her eggs, the male forfakes her, having performed the tafk, for which this luft was fo wifely defigned.

This wonderful copulation is perfomed in the the following manner. As foon as the male has leapt upon the female, he throws his forelegs round her breaft, Tab. XLVIII. Fig. I and II. *a a*, and clofes them fo firmly, that I found it impoffible to loofen them with my naked hands without wounding them; fo that I found myfelf under a neceffity of introducing an iron fpatula, between the female's breaft and the male's legs, the better to feparate them. The male moft beautifully joins his toes between one another, in the fame manner as people do their fingers at prayers. His head refts on that of the female, *b b*, but in the hinder part, his body hangs a great deal lower than her's, as he lies fo much more backwards than fhe does: this pofture has its ufe, which I fhall hereafter relate. The thumbs of the male's forefeet prefs with their thickeft fides againft the breaft of the female, and the extreme joints of the thumbs are bent a little.

Let the female fhake herfelf ever fo much at this time, the male never lets go his hold, even tho' fhe fhould get out of the water, fo that one may carry them any where in this pofture; which is likewife the cafe of garden Snails, when engaged in the fame bufinefs. Such is the male's eagernefs to act his part, that he is not to be parted from his mate, even by pulling him forcibly from her by his hind legs. Thus thefe little animals fwim, creep, and live together for many days fucceffively, till the female has fhed her eggs, which, at length, fhe does in a manner inftantaneoufly. I obferved, that when they breathed, during this intercourfe, the external fkin, which immediately covers the drum of the ear that lies under it, near the eyes, Tab. XLVIII. Fig. I. *cc*, continually heaved up, and then fell again againft that organ of hearing; and this alternate elevation and depreffion affords a pretty fpectacle, when they both breathe, and open and fhut their noftrils by turns.

It may be afked, at what time the male leaps upon the female? Whether it be before the eggs have paffed through the tubes, or after this, when they are already heaped up in the uterus? But this circumftance I omitted to examine. However, I cannot help delivering it as my opinion, that the male afcends the female when the eggs have been taken up by the tubes, and fome of them have begun to adhere to the uterus. My reafon for thinking fo is, that otherwife the male might defeat all his endeavours, by compreffing and clofing with his arms the mouths of the tubes. Perhaps, alfo, it is for this reafon, that fometimes fome of the eggs remain in the abdomen, after the others have been ejected. But a certainty, in thefe cafes, might be eafily obtained by diffection.

When, therefore, all the eggs of the female are got together in her uterus, the tubes are quite empty; and when every egg has received its coat of white in thefe tubes, or in the horns of the uterus, fhe throws them all out together by a fingle effort; and, while this is doing, it may be obferved, that the male acts the part of a midwife, and promotes the expulfion of the eggs by working with his thumbs, and compreffing the female's body harder with his fore legs. Thus, at laft, the eggs are difcharged at the female's fundament in a long ftream, *d*; and the male, who has no penis, immediately fecundifies, fertilizes, or impregnates them, by an effufion of his fperm, which he likewife difcharges at the anus, *e*, *. But as the eggs, rendered very clammy and glutinous by the white that invefted them, have grown together, had been compreffed in the uterus, they immediately, on being caft into the water, expand themfelves into their former round form, *f*. Hence appears the neceffity of the hinder part of the male's body hanging more backwards than the female's. As foon as thefe eggs have efcaped from the female's body, between her's and the male's hinder legs, and have been impregnated by the male's fperm, the two Frogs abandon each other. The male fwims off, and works his fore feet as before, though they had continued fo many days fucceffively, without the leaft motion, in the moft violent ftate of contraction.

The eggs thus dropt, immediately fink to the bottom of the water, unlefs hindered by weeds that grow in ditches, or the like; and in a few days they return to the furface again, if not ftopped in the fame manner. I opened a female about two hours after fhe had difcharged her eggs in a glafs veffel, where I had kept her for that purpofe, and found the ovary perfectly contracted, as I have reprefented it in the fourth figure of the forty-feventh plate, under the letter *k*. Befides, there ftill remained fome eggs in the abdomen, one in the ovary, and one likewife in the tube.

Upon my proceeding, after this, to examine the ovary, which was emptied of its eggs, I difcovered, in diffecting the body, three different fpecies of mufcles; namely, ftraight ones, interfected by four lines, and oblique defcending and afcending mufcles, lying under the former. When I had laid open the abdomen, I obferved a very remarkable fingularity in the ovary. In the firft place, I could difcern in it eggs of four different fizes and colours. Some of thefe were very fmall and white, Tab. XLVIII. Fig. III. *a a*; others a little bigger, and yellow, *b*; a third kind was a good deal bigger ftill, *c*, and of a dufky colour. There were likewife in this part a great many black little fpots, *d*, which, at firft fight, I took for fo many eggs; but the microfcope proved they were irregular particles, or eggs beginning to decay.

* It had been fuppofed that this method of impregnation was peculiar to Fifhes; but this is one inftance of the contrary. Something nearly analogous is the cafe with the Water-Newt, and probably future experiments will fhew it in other water animals.

On

On opening afterwards ſome of the lobes, all the foregoing particulars appeared ſtill more diſtinctly; the cauſe of the blood-veſſels amongſt the eggs being very diſcernible, *e*, as likewiſe the manner in which the eggs were placed upon the ſmaller ramifications of theſe veſſels. When I had attentively ſurveyed and conſidered all theſe things, I judged them to be the rudiments of the eggs, that were to be ſhed the enſuing ſeaſon; tho' afterwards the irregularity of their figure, and their difference in ſize, made me alter my opinion.

Finally, I found at the bottom of the membranes, which conſtituted the globules, and amongſt the eggs I have juſt now mentioned, ſome empty and very delicate membranes, Fig. IV. *aaa*, which had ſerved to inveſt the eggs that had been already diſcharged from the ovary; in the ſame manner as it appears in the cluſter of eggs in Hens, which ſtill retain, after the yolks have left them, the little membranes and cells which ſurrounded thoſe yolks; though, in courſe of time, theſe traces contract themſelves by degrees, and entirely diſappear. Theſe particles were moſt beautifully interwoven with blood-veſſels, to which they were fixed as to ſo many ſtalks, *bb*; as I have endeavoured to ſhew both one and the other, and at the ſame time one of the largeſt blood-veſſels, *cc*; but all of them conſiderably magnified.

This obſervation gave me reaſon to think, that the eggs I have been laſt ſpeaking of, might be, as it were, like fruits, which had not as yet attained their due point of perfection, and might wither and drop off, before they did ſo; and I found this to be the caſe, even with perfect eggs, that had remained in the ovary and abdomen, as I have in part repreſented under the letter *f*, of the third figure. Theſe little membranes, which I have been deſcribing, were torn, as it were, and ſo collapſed as to form a ſmooth plain ſurface; for which reaſon I exhibit only a few of them. But it is time to ſee now what becomes of the eggs, when they are diſcharged by the creatures now under conſideration.

Of the manner in which the young Frogs or Tadpoles grow in their parent's eggs, and are in due time hatched or delivered from them.

THE very next day after the eggs had been diſcharged, being the 18th of April, they were of the bigneſs repreſented at (1); and the albumen, or white, which ſurrounded them, was very inconſiderable: but I could ſee they grew from one minute to another, ſo that the day next following they were of the ſize at figure (2). The white, in proportion as the water gradually penetrated it, grew on every ſide more and more clear and tranſparent; but the inſide, which immediately contained the embryo Frog, rather looked like an agate. As to the fœtus itſelf, I could diſcern no alteration in it. But not content with external appearances, I reſolved to examine thoroughly theſe eggs; but the ſurpriſing toughneſs of the white threw ſuch obſtacles in my way, that all my endeavours ended in nothing: and though I, at laſt, ſtripped the embryo of the coats and other ſubſtances in which it was wrapped up, it was ſo cruſhed, and otherwiſe diſturbed by my handling it in the operation, that I could not by any means ſatisfy my curioſity.

This diſappointment obliged me to take another method. I put a large number of theſe eggs into different liquors, in hopes ſome of theſe fluids might prove a ſufficient menſtruum to diſſolve the white. At the ſame time I boiled, with the ſame view, ſome of theſe eggs in water; by which means I indeed ſucceeded, but not as perfectly as I deſired. However, I could ſee that the ſkin of the encloſed Frog was regularly wrinkled, as in boiling it had loſt by evaporation ſome of its humours.

On ſurveying the next day the eggs I had put into the other liquids, I found that the whites had been coagulated by the liquor, whoſe effects I firſt attended to, ſo as to appear of a beautiful roundneſs, like bunches of grapes. In colour they in a manner reſembled an agate, or the boiled egg of a Lapwing. The little encloſed animal was alſo coagulated, ſo as not to fall aſunder on diſſection, though I could then more eaſily diveſt it of the yolk.

In another liquor the eggs had acquired a purple colour; but very little of the white was diſſolved. I therefore paſſed to a third liquor, in which I found the white of the eggs was become more milky, and was a little diſſolved; and it had beſides loſt a great deal of its clammineſs and tenacity. The little Frog itſelf was increaſed to twice its ſize, and all its contents had in ſome meaſure contracted a colour: both which circumſtances afforded me a very convenient opportunity of examining thoroughly, and with great care, the firſt rudiments of this little animal.

The whites of the eggs in the fourth liquor had aſſumed a greeniſh hue, and wanted little of being entirely diſſolved; ſo that here alſo I could very conveniently ſurvey every part of the young Frog, eſpecially as this was alſo entirely coagulated in the ſame manner with the yolk of a boiled egg. Theſe were the different effects, on various parts, performed by one and the ſame liquor. On examining, therefore, with a microſcope, the encloſed young creature, I found it to conſiſt entirely of minute grains, which were in a manner uniformly divided, and were yellow and tranſparent, without

without any other contents or viſcera, that I could diſcover. The little animal was alſo divided throughout, as it were, into two parts, by a very conſiderable furrow or fold, Tab. XLVIII. Fig. v. *a a*. In the upper part there ſtill remained ſome traces of a little yellow ſpot, that appeared there by ſome little openings, cracks, or crevices, *b*. But on opening afterwards the egg, according to the courſe of the furrow juſt now mentioned, I could diſcern that, on one ſide of the fœtus, this furrow reached almoſt to the middle of its body, where this body was alſo ſomewhat convex, Fig. vi. *a*, in one part; and in the other part, to which that furrow equally penetrated, it was hollowed into a cavity, *b*, which received the convexity of the firſt. On the oppoſite ſide of the fœtus the furrow was not, by a great deal, ſo deep, *c c*, ſo that it juſt looked like a ſuperficial cut on the ſkin. The broken ſubſtance of the young Frog's body, compoſed of grains, *d d*, ſhewed itſelf in the place where theſe furrows terminated within.

I afterwards diſcovered in a perfect Frog alſo this parting or diviſion, which I at firſt obſerved by mere chance in the embryos of this animal; and this new diſcovery procured me great facility in accounting for that ſudden expanſion and elongation of the young Frog's body, on the fourth day, when it explicates or unfolds itſelf. Hence I believe, that one part of the unfolded embryo forms the head and thorax of the future perfect animal, and the other part the abdomen and tail, which grows larger and larger by degrees.

In the fifth liquor, where I had put ſome of the eggs, their whites were grown a little rediſh, and were almoſt diſſolved; but the encloſed embryos had ſhrunk up a little: by which means I obtained a ſight of a very limpid humour, that ſurrounded the young Frogs, and was itſelf encloſed in a delicate diſtinct coat or membrane. On examining theſe appearances with a great deal of attention, I diſcovered, that, on one ſide, this membrane looked like the allentoies, Fig. vii. *a*; and I could even diſcern, in the cavity of it, a little white coagulated particle, floating in the encloſed liquor. The furrow, already mentioned, was likewiſe viſible in the midſt of this egg, *b*; and, on the other ſide, the little yellow ſpot, diſcernible in the fœtus, ſhewed itſelf through the tranſparent membrane which inveſted it, *c*. This yellow ſpot differs in nothing from the other parts of the embryo Frog, except that the folds of the body are here larger than elſewhere; and for the ſame reaſon, in proportion as the Frog grows, this yellowneſs gradually wears away, and changes to black.

This ſecond diſcovery gave me room to ſuſpect, that the Frog's egg might likewiſe leave its amnion and its chorion; and I had afterwards the pleaſure of diſcovering theſe membranes, though I cannot take upon me to ſay, that they can be diſtinguiſhed one from another. But I know for certain, that the Frog is wrapped up in a coat or membrane, which is very diſtinctly conſpicuous; and that it floats, moves, and turns itſelf in a moſt limpid fluid contained in this coat, juſt in the ſame manner as the Chicken does in its colliquamentum, or white.

This ſingular obſervation made me exceſſively eager to ſearch, to the bottom, theſe wonderful and ſurpriſing myſteries of Nature. I therefore examined this egg again, touching it a little more roughly. By this means the allentoies dilated itſelf by degrees, Fig. viii. *a*, as I thus forced into that membrane all the liquid contained in the amnion; from which however, on removing the little inſtrument with which I had preſſed it, it returned to its proper ſituation.

At length, by treating this egg ſtill more roughly, I ſucceeded ſo far as to make the allentoies fall off from the Frog; and as, in ſo doing, I wounded the creature, I could diſcern its black fluid particles flowing into the allantois, and at the ſame time diſturbing the liquor of the amnion, which it diſtended, thereby giving it the ſhape of a Pear, Fig. ix. *a*; I therefore continued this operation, till every part of the allentoies was thoroughly expanded by the fluid particles of the wounded fœtus; as may be ſeen in the tenth figure, done after nature, but enlarged. With all this harſh uſage, I had not as yet broken any of the membranes.

I next took a ſurvey of the Frog's inſide; but I diſcovered nothing diſtinct enough to deſerve mention. I could only diſcern the little grains I have already deſcribed, and from which, as from a congeries of coagulated and united globules, this little animal ſeems to derive its origin. The menſtruums had produced in this granulated ſubſtance a beautiful variety of colours, as yellow, white, purple, and many others.

The obſervations already mentioned, had thrown ſo much light upon the ſubject of my preſent inquiries, that the third day after the eggs had been diſcharged, Tab. XLVIII. (3), I could pretty clearly diſcern the young Frog floating in the liquor of the amnion, and ſee that it was now gradually expanding itſelf. The whole egg alſo was grown much larger, by the water and food it had imbibed. The albumen that lay next the Frog was ſomewhat whiter than before; and I even thought that I could perceive in this ſubſtance ſome white veſſels, which, as I ſuſpected, might ſerve to encreaſe the white of the egg, and convey it to the embryo. We may therefore reaſonably conclude this has its umbilical veſſels, though too ſmall to be diſcerned. I unhappily neglected this day to put any eggs into the menſtruums I had prepared to coagulate them, and thereby to obtain an opportunity of looking for theſe umbilical veſſels.

On the fourth day 4 4 4 4, all theſe particulars were ſo viſible, even without the aſſiſtance of a microſcope, as not to leave the leaſt room to doubt of their exiſtence; eſpecially as the colliquamentum, or white, and the coats investing the embryo, were likewise greatly increased in size, and the Frog had unfolded and displayed itself under a variety of forms; as may be seen in the figures I have given, to represent them of their natural dimensions.

The same was to be seen on the fifth day, and formed a most surprising and beautiful appearance. I could now also discern by what means the chorion and amnion dilate themselves gradually, in the middle of the white. The ring also, formed by the white vessels of the chorion growing round its circumference, was now extending itself; but with all this, no umbilical vessels yet appeared in the colliquamentum of the amnion, though this liquor was as transparent as chrystal. I could now also most distinctly discern the division of the young Frog into head, thorax, belly, and tail, as well as the manner in which it was beautifully adorned about its thorax, and near its head, with some black spines, disposed like a border, and highly worth our notice, as I shall hereafter explain. All these things may be seen in the figure, number 5, Tab. XLVIII.

I must here observe, that I could not now any longer discover the allentoies; but whether the sight of it was intercepted by the dilatation of the chorion or amnion, or whether it had only consisted originally of the folds of these membranes, or in what other manner this difficulty may be explained, I cannot take upon me yet to determine. It was matter of great entertainment to me, this day, to see the embryo Frogs rolling and tumbling about, almost perpetually, in the surrounding amnion.

On the middle of the sixth day I could perceive, that some of the young Frogs had disengaged themselves from the chorion and amnion, and deserted the albumen, or white of the eggs; whilst others were only preparing to break loose, and others again had not even attained so much strength and perfection as these. I observed also, that some of the eggs had increased in size, without unfolding themselves; and these, I believe, were such as had not been impregnated by the male's sperm. I afterwards met with two albumina, or whites, which did not now contain, and never had contained, any Frogs, though I could discern in them a white spot; so that perhaps these were imperfect eggs, which had dropt from the ovary with the rest, and had received equally with them their proportion of albumen, in passing through the tubes. Thus did I, in this subject, discover a great many of Nature's miraculous operations.

The tenth day (10) I had the pleasure of seeing the young Frogs, which had deserted their albumina, in an almost perpetual motion, swimming alternately to this their primitive habitation, and then from it again, for the sake of rest and food. These Frogs were of the form represented by the figure, number 10, and they were grown very little larger; but I thought it very remarkable, that the little black appendages, like borders, before mentioned, were greatly increased in bulk. These spines, it is probable, were intended by Nature to assist the little animal in swimming, as well as in remaining quiet and reposing itself in the white. They greatly added to the beauty and singularity of its appearance, according to the judgment I had at first sight formed of them.

On the 15th I diligently surveyed, through the microscope, the external parts of the young Frog, as I have represented in two separate figures, of its natural size, in Fig. XI. and in Fig. XII, *a*, of the size given by the microscope, when laid upon its back. I could now most plainly discern its division into head, thorax, belly, and tail. The eyes lay on each side of the head, Fig. XII. *a a*, and were beginning to project a little, though they still appeared as if they were shut. On the fore part, between the eyes, appeared the animal's wide mouth, *b*. A little lower than the head, there were fixed to the thorax several particles in two arrangements, twelve on a side, very much resembling, in form, the little fimbriated appendages already mentioned; which I here represent as rising from the sides of the body, *c c*. I observed, that the little Frog could expand these particles at pleasure, and draw them up towards the abdomen, and afterwards reduce them to their former situation. The division of the thorax and abdomen was pretty distinct. In the belly lay an intestine, which swelled beyond the external surface; and, tho' not completely coiled, formed a great variety of windings in its way to the root of the tail, where it at last seemed to terminate, *d*. The *e e* tail on each side was somewhat transparent, but more opake in the middle, owing to its being thicker thereabouts, and to its having also there a great many cartilaginous parts, each furnished with its peculiar muscles for moving the tail. I could therefore plainly discern, that this cartilaginous and muscular portion of the tail, extended to its very extremity, *f*, in the midway between the two membranaceous lateral one. The skin of this young Frog, viewed with the microscope, looked exactly as if it was thick set with black spots, upon a lighter ground, which appeared in their interstices.

On my dissecting this animal, and opening its abdomen for the first time, the intestine appeared very conspicuous; but so delicate, that, with the slightest handling, it dissolved into a great many globular particles; as did likewise the appendages, which were disposed with great art, like beautiful round spots, on each side of the thorax. Even the skin itself, when handled, fell into particles of the same form. I could not discover the stomach, on account of this wonderful tenderness of the animal's internal parts. I thought, indeed, I saw the heart; but I could not perceive either blood or vessels. The contents of the thorax fell also into little globules, in the same manner with the other parts already taken notice of. The eyes exhibited themselves much more distinctly within the head, than in its outside. The cartilaginous rudiments of the tail were grown to such fuch a degree of firmnefs, that I could but juft feparate them from the adjacent parts. Tho' the tail moved about pretty violently, I could not clearly notwithftanding difcover its mufcles, as well becaufe they were extremely minute, as becaufe the fame wonderful fluidity and fpherical configuration fhewed itfelf in the parts of thefe organs of motion. However, I could plainly perceive them growing in another little Frog, near the root of the tail. The colour of the animal's internal parts was a dark gray. This proved another obftacle to my anatomical inquiries, by caufing, in all their appearances, an immediate confufion. I could difcover nothing more than I have already mentioned in fome of thefe Vermicles of Frogs, which I had fet apart as larger, and confequently fitter for diffection than others. I could only obferve, that thofe round particles or grains, of which I faid, at my fetting out, that the eggs confifted, went likewife to compofe the fkin and internal parts of the Frog. A circumftance that could not fail of furprifing me greatly, and the more fo, as they were confiderable and diftinct enough to be feen with a common microfcope.

At this time, namely, on the 2d of May, I caught a Frog, which had not as yet difcharged her eggs; for which reafon I opened her, and fed with them my young Frogs. This animal's miffing the ufual feafon for this operation, might be owing to her wanting a male, or to her being in a fickly condition. Be that as it will, her eggs did not unfold themfelves on being thrown into the water, like the others.

On the twentieth day of thefe experiments, which was the 7th of May, the fimbriated appendices, Tab. XLVIII. Fig. XII. *cc*, had begun to difappear; and were no more to be feen on one fide of a Frog, fomewhat bigger than the reft. This made me eager to inveftigate the caufe of fuch a change, efpecially as the appendages of the left fide, which had not as yet totally vanifhed, ftill continued in motion. In the courfe then of my inquiries for this purpofe, I obferved, that the fkin of the body, which lay between thefe particles, had grown over fo as to cover entirely that of the right fide; and had already begun to take in, after the fame manner, the particle on the left. I afterwards difcovered, that the two particles I have exhibited as lying on the animal's thorax, under its head, with a direction downward, had each of them a paffage to that part under the fkin, which appeared to extend towards the fimbriated appendages; but I could not be fure of this circumftance, on account of the extreme tendernefs of all thefe parts in the young Frog. However, I hence, with great reafon, fufpected that thefe particles might afterwards poffibly grow into the young Frog's branchiæ; for I alfo obferved, that the particle, which the fkin had already over-run on every fide, had likewife loft fomewhat of its original appearance and form.

The protuberant inteftines might now be more eafily difcerned; and their termination, at the place already mentioned, Tab. XLVIII. Fig. XII. *d*, was become much more confpicuous. The pulfations of the heart, at this period very ftrong, were likewife very vifible through the tranfparent fkin *. In the tail the cartilaginous vertebræ, and the mufcles fixed to them on each fide, fhewed themfelves very diftinctly, and, in a beautiful manner, refembled a goofe-quill branching on both fides into fmaller feathers; for thus, nearly, thofe mufcles hung to the cartilages which they were to move.

In diffecting the little animal, I found its inteftines were increafing every way by degrees, but in length efpecially; to favour the increafe this way, they were rolled up into coils, on account of the fhortnefs of the body in which they lay. But they were, however, as yet tender, and their external coats ftill confifted of little globules. I could now juft difcern the ftomach, as likewife the liver and gall-bladder of an aqueous or watry colour, and compofed likewife of fpherical particles. The entire liver confifted alfo of grains of the fame form, and the very heart itfelf, which I took panting out of the body, and at every fyftole ufed to fill with thofe grains, the little tide of whitifh blood it drove into the arteries.

Upon the whole, it was manifeft, that the heart was formed in the little Frog, in much the fame manner with that of Chickens, according to the account given us of them, by that illuftrious anatomift, Marcellus Malphigi. The blood-veffels alfo, now fhewed themfelves. The eyes, and all their humours ftill confifted of little globules; as did even the black part of the uvea. The mouth, contracted like the mouths of Fifhes, was grown a great deal more wide and fpacious, tho' not fo large in proportion, by many degrees, as that of a Frog, arrived at its full growth; or even of a young Frog that has juft thrown off its tadpole fkin; as fhall be illuftrated with a figure in its proper place. As to the particles which formerly lay on the outfide of the thorax below the mouth. I could no longer fee any thing of them; nor have I made any other obfervations concerning thefe appendages, befide thofe already mentioned.

May the twenty-third, which was the twenty-fixth day after the young Frogs had left their white fubftance, I received a fupply of little Frogs from the country, in a flat-bottomed earthen pot.

Having before diffected all thofe that I had hatched and and raifed myfelf, left the little animals fhould be killed in the paffage by the continual toffing of the water; and in order to afford them refting places, I ordered, by way of prefervation, that the pot fhould be nearly

* No creature affords more entertainment or inftruction, by the microfcope, than the Frog. The animalcules in the femen of the male we have already mentioned. The circulation of the blood is feen in the mefentery, by the help of the folar microfcope, more beautifully than in any other creature.

filled

filled with duckweed: and have with this ſoft matter, only a little water. This contrivance anſwered ſo well, that I received all the Frogs in good condition. The ſmalleſt ſpecies of them was of the ſize exhibited in thę the thirteenth figure, Tab. XLVIII. Fig. XIII. and theſe were the Frogs I now took under my conſideration, as I had ſet out by conſidering thoſe of the ſmalleſt kind. This pot contained a good many Frogs of twice the ſize of the former, but they were the offspring of a larger ſpecies; ſo that I only made uſe of them to obtain better notions concerning ſuch parts of the animal, as I had before diſcovered them in the ſmaller ſpecies. It is now time to deſcribe the many curious things that occurred in the courſe of my ſuperficial ſurvey and anatomical inquiry.

The firſt thing that appeared worth notice, without diſſection, was the wonderful contrivance and conſtruction of the mouth, Fig. XIII. *a*. But as theſe parts of the young Frog are too ſmall to be properly repreſented in figures of their natural ſize, I ſhall rather exhibit them as they appear thro' the microſcope, on laying the creature upon its back, with its viſcera ſeparated one from another. The external opening of young Frogs mouths, is by no means placed in the anterior extremity of the head, as it is in moſt Fiſhes, and even in grown up Frogs, but opens in the thorax a little deeper under the head, as in the Shark, ſo that the young animal is obliged to turn itſelf on its back, in order to ſeize any thing that floats upon the ſurface of the water; and I have often ſeen it throw itſelf into this poſture, either when it happened to be very hungry, or intended to diſcharge the air from its lungs: upon theſe occaſions, it turned ſo nimbly, that my eye could ſcarce follow it.

The aperture of its mouth conſiſts of an under jaw *a a*, Tab. XLIX. Fig. I. and a upper one *b*, both moveable, of an extreme blackneſs, and armed with very ſmall teeth like a ſaw, with which, conſidering its ſtrength and ſize, the little animal is able to bite exceeding hard. Theſe parts ſeem to be made of a ſlender, horny, and pretty flexible bone. There are, moreover, both above and below the opening, a great many little horny bones of the ſame kind, furniſhed with a multitude of little black teeth. All theſe little bones are placed upon ſome muſcular and very white plaits, which ſerve the animal like ſo many lips, and ſhut its mouth, or keep it ſhut; they firſt ſeize the prey it aims at, and then help it to draw gradually into its mouth the food it has taken hold of: for this reaſon the young Frog can move open and cloſe all theſe muſcular parts in a great variety of ways. The ſkin lying on each ſide beneath the mouth, conſiſts of a great number of white papillæ *cc*; ſo that it affords in the Frog itſelf a very beautiful appearance. A little lower down are the protuberant eyes *dd*. The ſkin that covers theſe and every other part of the body are moſt neatly coloured like variegated marble with gold ſtars and ſpots as it were upon a black ground. This animal, when turned ſo as to lie on its back, ſhews on the forepart above the eyes, its noſtrils, thro' which it breathes, lifting the head for that purpoſe, a little above the ſurface of the water; and on this occaſion it moves thoſe parts, which it alternately expands and contracts, in a very elegant manner.

On opening at this time the little animal's thorax, there appear very diſtinctly in this part, and a little below the place where the bone of the breaſt grows, the branchiæ, or gills, divided on each ſide into four primary orders, or rather ranges *ee*. We may even ſee how each of theſe orders is again, as it were, ſubdivided into a great many globular prominent parts, along which the blood-veſſels run in vaſt numbers, and in an uncommon and very beautiful manner. At the ſame time the lungs are alſo ſeen lower down in the abdomen *ff*, and they are almoſt always found ſwelled with air, in the manner I have repreſented the right portion of them; where I have likewiſe taken occaſion to exhibit the blood-veſſels diſpoſed over this organ. The left portion is repreſented as it appears when collapſed; for then there remains in it but a very inconſiderable portion of air, which, on account of the extreme delicacy and tranſparency of the membranes conſtituting the pulmonary lobes, appears no otherwiſe than as a naked bubble of air, lying externally on the part whoſe continuation really encloſes it.

This is a moſt curious obſervation, as it informs us there is an animal, which, at one and the ſame time, has both gills and lungs, both ſerving to circulate, cool, alter, and purify the blood. It is probable the air, in this creature, mixes with the blood in its paſſage through the lungs; and that afterwards, in company with this fluid, it viſits every part of the body; whilſt the water, by paſſing thro' the mouth at the gills, has at the ſame time the very ſame effect.

Theſe gills are no other than the little fimbriated appendages, which I repreſented bigger than the life, in Tab. XLVIII. Fig. XII. as hanging on the outſide of the body; and which, on being taken in by the creature in its growth, are now advanced to the important office of gills. It is in this manner exactly, that the vitellus of the Chicken, which at firſt lies without the abdomen, comes afterwards by degrees to be ſhut up in the belly, as Dr. Steno firſt deſcribed this natural proceſs, which he likewiſe illuſtrates with an accurate figure; and immediately after him, that curious Engliſhman, Walter Needham: for theſe two gentlemen, who were quite unacquainted with each other, made this diſcovery at the ſame time, in different countries. Theſe borders or edgings are very diſcernible on the little Frog's firſt appearance from within its albumen, and while they continue on the outſide of the body. The learned Oligerus Jacobæus was acquainted with theſe particles, as appears by his being the firſt who gave a figure of them, with a ſhort explanation, in which he juſt takes notice of their diſappearing in time; but this circumſtance might be eaſily known, and without the help of diſſection, and I took notice of it myſelf more than twelve years ago. The gills heretofore deſcribed, may be likewiſe ſeen within in the Frog's mouth, through which the water flows upon them, and is then diſcharged, after altering the blood that paſſes through theſe organs.

Nor could I ever yet diſcover, that theſe branchiæ or gills, have any openings on the ſides of the body, as is uſually the caſe in fiſhes.

Here it may be probably aſked, whether the blood circulates in the young Frog, both through the gills and lungs? This I cannot abſolutely determine; for whilſt I was engaged in theſe obſervations, I was diſturbed with the caſes of many who were dangerouſly ſick, which prevented my having time and leiſure for examining this matter in the largeſt young Frogs, one of which I have repreſented, Tab. XLVI. under No. V. otherwiſe I had reſolved to render theſe obſervations on the generation and change of young Frogs as complete as poſſible. I muſt therefore deſire the reader to accept what I now exhibit on this ſubject, as the prelude only of a more perfect work, to be hereafter publiſhed. Though I have already obſerved many things concerning this matter, I have not ſuch confidence in my memory, as to preſume to publiſh, before I re-examine them.

In order to make ſome anſwer from my former obſervations to the queſtion I have juſt now propoſed, I am thoroughly perſwaded, that the greateſt part of the blood circulates in the young Frog through the gills; and that only a ſmall part of it is conveyed through the lungs; and this deſigned probably only to nouriſh them, and to ſupply the remaining maſs of blood with air. The reaſon why I propoſe this opinion is, that only a very ſmall portion of the blood circulates thus in full grown Frogs, in which the gills, being probably thrown off with the laſt ſkin which the Tadpole caſts, wholly diſappear; and, on the other hand, the greateſt part is after this diſtributed into the whole body, out of the heart through the arteries, without touching the lungs. This is made evident in a letter, which I formerly wrote to the celebrated Oldenburg, ſecretary to the royal ſociety of London, and which is to be found in the philoſophical tranſactions of that ſociety. I hope alſo, that by this obſervation, I have at length proved it, againſt the opinion of the famous Malpighius and Needham, who think the blood is perfected in the lungs; that ſanguification, or the making of blood, muſt be wholly attributed to the liver. I am perſuaded, that I can demonſtrate it very eaſily: though ſome, ſtimulated with envy and vain glory, bark againſt it, like dogs againſt the glittering brightneſs of the moon. My experiments concerning this matter, indeed, penetrate further than any perſon hath ever probably thought. But I return to the Tadpole or young Frog.

The heart, Tab. XLIX. Fig. 1. *g*, is placed between the gills in the Tadpole; and out of it, one may very diſtinctly ſee produced the great artery: this is divided into two branches; and theſe are further divided into very conſpicuous ſprigs or ſhoots, which have all gills annexed to them: but whether ſome of thoſe branches are likewiſe tranſmitted to the lungs, as is the caſe in full grown Frogs, I could not at this time, for the reaſons beforementioned, examine: I am ſtill doubtful alſo, whether all theſe ſhoots are diſtributed to the gills alone.

Near the heart is placed the auricula *h*, which has not yet ſuch a ſituation or figure, as it has in full grown Frogs. But in the examination of the auricula, and its veſſels, I have not yet arrived ſo far as to ſatisfy myſelf: therefore, I cannot exactly declare, whether thoſe two veins, which I delineate under the Auricula, reach to the gills, and carry back the blood from them to the heart, or whether they communicate with the veſſels of the lungs. All theſe matters ſtill remain to be inquired into. But for this reaſon, I do not ſcruple to delineate thoſe parts, as they appeared to me, without examining them more exactly.

Below thoſe two veins is ſituated the vena cava and liver, *i*; this I obſerved to be divided, as it were, into four lobes: it is at this period whitiſh, and ſomewhat rediſh. It is plainly diſcovered, that the liver is compoſed of very regular glandulous granules, which one may take for very ſmall glands. Near the liver in the Tadpole is placed the gullet, *k*, which deſcends from the mouth to the ſtomach, and is delineated here in that form. But, in order to avoid confuſion, I delineate the gall-bladder, *l*, near the other ſide of the gullet. That little bag of gall was at this time of a white, diaphanous hue: nay, the bile itſelf was limpid and perſpicuous, and without any bitterneſs; though in the full grown Frogs, it is ſometimes ſo green and fluid, that it may be uſed to draw lines. The fluidity of the gall ſeems to me to depend on its piercing bitterneſs, which is manifeſt ſome months afterwards, if paper, rubed over with ſuch gall, be put into the mouth. The ſpleen in the Tadpole is very ſmall, triangular, but ſomewhat irregular, and much more red than the liver: this is likewiſe the caſe in full grown Frogs.

There was nothing more beautiful to obſerve in this diſſection, than the courſe of the gullet, ſtomach and inteſtines; for theſe parts were obſerved to be very admirably convoluted in the body of the Tadpole. The firſt ſinus, into which the gullet was twiſted, was about the liver, Tab. XLIX. Fig. 1. *m*, under which I have delineated, *n*, a certain portion of the meſentery, together with its blood veſſels. The ſtomach was in the beginning, and in its ſtate of accretion, like a piece of red fleſh, which being partly ſituated over the gullet and ſmall guts, began *o* to ſwell and grow thick. But there was likewiſe obſerved a great number of blood veſſels, which diſtributing themſelves through the ſtomach, formed as it were a beautiful net.

I here diſcovered moſt clearly, that the ſtomach in the beginning of the young Frog's accretion, did not yet perform its office, which was in the mean time performed by its gullet and

 inteſtines

inteſtines, which were for that reaſon made proportionably larger and longer in the young Frog, than even in the full grown one. On meaſuring the length of the inteſtines in this little creature, I obſerved it to be five inches. When I thoroughly viewed the contents of the gullet, ſtomach and ſmall guts, I obſerved they were all of the ſame nature, and contained ſome parts, of aquatic plants, little grains of ſand, clay or mud. Therefore, when I fed theſe young Frogs with Duckweed for ſome time in my chamber, in ſtone baſons, I obſerved that they eat all the roots of it ſo clean, that none remained; but not the round little part or leaf, which is full of air, and ſwims on the ſurface of the water. But afterwards, when they had nothing to eat under the water, I obſerved them continually rolling about on their back for hunger, and conſtantly catching the reſidue of the Duckweed in their mouth, though it was too big for them to ſwallow.

At the ſame time, I obſerved alſo, that the orbicular leaf of the Duckweed is not only full of air-bubbles, and for that reaſon neceſſarily floats on the ſurface of the water; but that even its very root of the plant, contains air, tho' not in a proportional quantity: this is probably the reaſon why the root ſubſides. I further obſerved, that the extremity of the peduncle, or root of the Duckweed, is thicker in proportion, and more porous than the ſtalk itſelf: and conſequently the nouriſhment ſeemed to me to penetrate through that extremity to the leaves. I likewiſe obſerved, that when I nurſed up one plant of Duckweed in a baſon of water, and expoſed it to the rays of the ſun, it inſenſibly put forth many roots; nay, that the very leaf of theſe little plants multiplied and increaſed into two, three, or four other leaves; the leaſt of which, afterwards ſeparating from the parent, formed ſeveral other ſmall ones; ſo that this little plant ſeemed to multiply itſelf without ſeed, in a very ſhort time. I had indeed reſolved, yet more accurately, to inveſtigate and delineate theſe things: but the reaſons before mentioned, have likewiſe diverted me from this reſolution.

Some years ago, examining the tubercles, which are found on the back of Fern-leaves, I obſerved that they conſiſted of ſome thin plates, or laminæ, in which the pods, containing the real ſeeds of the plant, were encloſed: though many authors deny that this, and ſuch like ſpecies of plants have any ſeed *. Since the art and ſtructure obſervable in theſe pods is admirable, I ſhall give a brief deſcription of them, until I have time to delineate them magnified; as I have formerly done to oblige Dr. Arnold Syen, profeſſor of botany, to whom I freely communicated this uncommon obſervation, ſince it regarded his profeſſion: of which, however, no further notice need be taken here.

Thoſe pods are of a round figure, and are compoſed, as it were, of two hemiſpheres, placed cloſe to each other; but they may be parted in the middle. About this joint or ſeam is beautifully twiſted a little herbaceous cord, which keeps the two ſegments of the pod in their ſituation. One extremity or baſis of this little rope grows to the fern-leaf; but the other is affixed to the lower hemiſphere of the pod; and at length, after ſurrounding the whole pod, it terminates in the upper part of it.

In the cavity of this pod the Fern-ſeed lies, and it is indeed ſo ſmall, that it is with great difficulty to be diſcerned by the naked eye; and when blown upon, it vaniſhes into the air like fine duſt.

But this is only a ſmall part of thoſe beauties that are obſerved about the pod, and its cord. I beg leave to obſerve from hence, that when the ſeed grows ripe on the inſide, and the pod dries away, then the cord, twiſted round the pod like a rope, is ſo ſtrongly curled, on account of its contorſions, that it makes the pod fly into two parts, and forces a paſſage for the ſeed to diſperſe itſelf.

This may be ſeen clearly and diſtinctly, if the ſeed be examined in autumn with a microſcope: for as the head is, under this inſpection, very near this ſeed, I have often obſerved, that a great number of theſe pods, burſt aſunder by force of the twiſted cords, which are contracted by the breath and heat of the body, and the ſeed, is by this means thrown out. But theſe things are only ſaid occaſionally in this place †.

The pancreas in the Tadpole was obſerved, Tab. XLIX. Fig. 1. *p*, to be ſituated near the ſtomach, and compoſed of diſtinctly conſpicuous glandules. Below the ſtomach appeared *q* the ſmall gut, with its blood-veſſels and contents, which were of a greeniſh tranſparent colour. But the convolutions of the inteſtines exhibited the moſt beautiful ſight of all; for theſe were orderly and regularly rolled *r r* into two diſtinct ſerpentine forms. One of their extremities was joined to the rectum, *s*, which at length conſtituted the fundament between

* Every part of natural hiſtory is greatly improved of late time. This author firſt diſcovered the ſeeds of Fern, unknown to former writers; and we have ſince diſcovered thoſe of Duckweed, which were unknown to him. This little plant is now known to produce its like in the manner of all others. Small as the whole plant is, it produces flowers of all kinds from the ſame root. In ſome of them are the filaments, two in number, and a ſingle ſtyle riſing from a ſmall oval rudiment of a fruit: in others, there are no filaments, but only the rudiment of a fruit with its ſtyle. The cap which contains theſe, is alike in both kinds; it is rounded, and ſplits on one ſide: there are no petals in either flower. The rudiment of a fruit decays, and comes to nothing in thoſe flowers which have the filaments with it; but in the others it becomes a globous ſeed veſſel, terminated by a point, and contains ſeveral oblong ſeeds. This is eſtabliſhed on the opinions of Micheli, Dillenius and Buxbaum, and is confirmed by Linnæus, and by experience.

† The world owes great acknowledgments to this author for many diſcoveries; and he with juſtice claims that diſtinction, in regard to the ſeeds of Fern, of which he treats more largely hereafter. The ſcience of Botany is ſo far improved ſince his time, that we have diſcovered diſtinctly the ſeeds, and their peculiar diſtribution on the leaves, in all the capillary plants. In Oſmund they are encloſed in diſtinct globular capſules, which burſt ſideways; in the Louchilis they are laid in lines, like creſcents, under the hollows of the leaves; in Hartſtongue and Trichomanes they are diſpoſed, in ſtraight lines, under the diſk of the leaf; in Polypody they are arranged in round dots; in the true Maidenhair in oval aſſemblages, at the t ps of the leaves: the Horſetail has them in oval ſpikes; and the Adderſtongue in cells, placed in two rows along the ſpike. Theſe plants are now found to belong diſtinctly to the four kinds; and in the Rutta Muraria they cover the whole under-part of the leaf.

the two hinder legs, *t*. The difference, however, between the fmall and great guts was not very confiderable in the Tadpole; nor is it very remarkable in the human fœtus, in which there is, at firft, very little difference between the fmall gut, colon, and rectum; as I can demonftrate in a human fœtus fix months old.

The moft remarkable thing in this little animal was, that only the rudiments of *u u* the two hinder feet of the Frog were yet feen; and from them the toes, not yet ftrengthened inwardly with bones, began to fwell, as a branch does out of a tree; though the figure and conftruction of the feet was, however, pretty perfect and evident. But as to the two fore legs, not even the leaft veftige of them yet appeared outwardly, becaufe they lay *x x* hidden, covered and enclofed under the fkin: nor did they come in view before the fkin was cut open in that part, and then they were feen fituated above the lungs and below the gills, though they were not fo perfect as the hinder feet.

It is evident, from what has been faid, that this animal may and ought to be confidered, in its original, as a real infect, fince it hides its limbs under the fkin, and thefe increafe there until the change of the laft fkin is near at hand; at which time it is obferved in infects, that they are, as it were in an inftant of time, transformed into other creatures, and exhibit to view fuch limbs as they did not before appear to have. The fame thing likewife holds in young Frogs or Tadpoles: wherefore this animal ought to be placed in the fecond order or clafs of our natural changes, unlefs the juft laws of method had commanded me to treat of it at the end of this work, in order to make the likenefs between animals which have a red blood, and thofe which contain white, yellow, or green blood in their heart and veffels, the more evident.

As we fee infects lofe many parts with their old fkin, this is likewife the cafe in the Frog; which, befides other things, plainly cafts off its mouth and tail: fo that, however admirable the art, order, conftruction, and parts of its members may appear to be; yet the nerves, arteries, veins, cartilages, mufcles, and many other remarkable parts, which gradually vanifh, and are, as it were, become infenfible, are deftroyed at once, ceafe their motions, and ftop their feveral functions, on the change. Are not thefe changes admirable? And do not they lay before our eyes the omnipotent hand of God, confpicuous in his inacceffible radiancy and infinite majefty? He, in this cafe, forms another out of one and the fame animal, which though different in appearance, yet remains one and the fame creature. May not the refurrection of the dead be exemplified in this illuftrious inftance? All this is very elegantly manifefted in various infects.

As the want of fubjects now prevents my being able to inveftigate further the moft artificial compofitions and changes of the limbs in the Tadpole, I fhall here defcribe only the mufcles, which are moft regularly placed in the middle of the tail, and merit very particular notice. Thofe mufcles are laid fomewhat obliquely, and converge, Tab. XLIX. Fig. I. *y y y*, to each other from the two fides of the tail towards the middle; and each of them is likewife divided into many moving fibres. That this may appear the clearer, I have delineated them as if they lay outwardly on the fkin. On each fide of the mufcles is feen *z z* the membranous fkin of the tail, marked with beautiful points: by the help of this part the Tadpole moves its tail, and fwims, fince it ufes it like an oar, to pufh its body forward, with a ferpentine motion.

Before I proceed to other obfervations, which I have made on the full-grown Frog, I fhall give the method whereby the Frog changes its fkin. I would have it obferved, that I here treat of the largeft fpecies of Tadpoles, fince the other kinds are much fmaller. To which I muft add, that I increafed it a little above its natural fize, in order to explain more intelligibly the metamorphofis of the fkin. The time when the young Frogs begin to caft their fkin, and to put on the form of a Nymph, is with us about the middle of June, or fomewhat later; that is, a little more than two months after they come out of their eggs. When this time approaches, the fkin of the young Frog is firft ufually burft in the back, near the head, and through this chink the young Frog immediately puts forth its head. Then is feen the mouth lying, Fig. II. *a*, in the Tadpole's exuviæ; and this is obferved to differ much, *b*, from the wide opening of the Frog's mouth. Then the Frog turns out its firft pair of legs, which lay till now hidden under the fkin, *c c*, and at the fame time it preffes back the fkin towards the hinder parts. Thus the reft of the body, the hinder legs, *d d*, and alfo the tail, are ftript of their fkin: after which we fee the tail contracted more and more every day, until at laft no veftige of it appears. If the Frog thus produced be a male, two pneumatic kidneys *e e* are difcovered on each fide of the head, behind the eyes; and the great toes of the fore feet appear alfo thicker and longer *f f* than in the female. But what parts in particular are left in the exuviæ, and whether the gills be difcovered adhering to them, I have not yet examined. After the fame manner Toads and Water-Newts caft their fkin.

Of

Of the circulation of the blood in a full-grown Frog.

THE manner in which the blood circulates in the full-grown Frog, is not a point of ſmall moment: indeed, it very much recommends comparative anatomy, ſince, when that is not thoroughly known, it ſeems that one cannot arrive at the real knowledge of the uſe of the viſcera. The famous Malpighius, Needham, and many others, ſay that the Frog has viſible lungs and reſpiration. Nay, they alſo think that the blood circulates through the lungs, is there elaborated, leſſened in the globules, and brought to its full perfection: and hence the office of ſanguification, which, in former ages, was ſuppoſed to be done by the liver, is now transferred from thence to the lungs. Beſides, ſince the ſame gentleman has obſerved gills in Fiſh anſwering the purpoſe of lungs, thro' which all the blood circulates; and as they ſaw the water ſtrike againſt theſe in the manner as the air does againſt and into the lungs, in other animals, they have therefore made the gills perform the office of making blood.

I confeſs, this opinion is very ingenious; if it be ſuppoſed, that the liver does in no wiſe contribute to make blood. But from whence ſhall ſanguification be derived in this animal, which has lungs; but at the ſame time they are ſo circumſtanced, that the blood does not paſs thro' them, but is immediately diſtributed all over the whole body, out of the ſingle ventricle which their heart hath, without touching the lungs? This plainly is the caſe in Frogs. The ſame thing, probably, holds in Toads, Water-newts, Lizards, Chameleons, Tortoiſes, Serpents, and other creatures of that kind; all which I have obſerved to be provided with membranaceous lungs: tho' I have not yet accurately examined their blood-veſſels. We ſhall certainly be obliged to return to the liver, and reſtore it to its former degree of dignity. Nay, this holds more ſtrongly in the Frog, which is deſtitute of the lacteal veins: ſince its chyle muſt, for that reaſon, neceſſarily enter the great numbers of its meſeraic veins, and be thus conveyed thro' the vena porta to the liver. In the extremity of this vein, the blood, which is to paſs from thence into the cava, is broken and divided; and it ſeems to me to acquire its laſt perfection in the cava itſelf. As, I am confident, I ſhall, at ſome time, more fully demonſtrate, with reſpect to thoſe animals, which have lacteal veins. But I cannot now, for want of time, finiſh the experiments, which I have began, concerning this ſubject: and which, tho' not many in number, are yet ſo important, as to promiſe great diſcoveries.

Having premiſed theſe things, I ſhall now briefly deſcribe the principal arteries and veins in the Frog, and ſhall ſhew the manner in which the blood circulates thro' them. The Frog's heart, Tab. XLIX. Fig. III. *a*, as is the caſe in moſt Quadrupedes, is found ſituated in the cavity of the breaſt, which is indeed very ſmall. To the upper part of the heart, the auricle *b* is obſerved to be joined: but it has, like the hearts of Fiſh, only one ventricle, out of which likewiſe there iſſues only one artery; which is in the beginning conſiderably muſcular, and ſufficiently dilated, and immediately afterwards dividing into two trunks; one of which is detached to the right region *c*, the other to the left region of the breaſt *d*. Each of theſe arteries, which are like the ſubclavian veins, is further divided into three principal branches. The firſt of theſe, which is the leaſt *ee*, ſtretches on each ſide to the lungs, and gives them nouriſhment: and therefore I call theſe the pulmonary arteries, and they are of the nature of thoſe called Bronchials in man and brutes. Theſe, in their courſe to the lungs, are commonly divided into three branches, which I here exhibit as cut off; and after this ſtretching to the coat that ſurrounds the lungs, thereon form a very admirable piece of net-work, and communicate with each other by ſeveral anaſtomoſes: hence they alſo paſs down by very ſmall ſhoots, into the inward irregular veſicles of the lungs, among which the pulmonary vein is diffuſed, and with the latter they form a very conſpicuous anaſtomoſis, viſible even to the naked eye. This is manifeſt, if theſe veins and arteries be filled with quickſilver. I keep ſome prepared in this manner. Out of the pulmonary arteries likewiſe proceed two ſmall branches, Tab. XLIX. Fig. III. *ff* on each ſide, turning upwards, which are diſtributed thro' the parts of the mouth.

The ſecond pair of the principal branches, ariſing out of the trunk of the great artery, are obſerved to be dilated into two remarkable ſwollen knots; theſe are of a grayiſh black colour *gg*, in the living Frog. Both theſe arteries are after this extenuated, and, together with the little branches iſſuing from them, ſeem deſigned only to ſerve the muſcles of the mouth, and thoſe of reſpiration. But as each of them aſcends higher, it is again dilated into a knotty little bladder. I ſhould think theſe arteries are duplicates of the nature of thoſe which before ſerved for conveying the blood to the gills. This I cannot affirm for certain; but it may be hereafter examined into by repeated diſſections.

The third pair of the primary branches are particularly worthy of conſideration; ſince theſe properly conſtitute the trunk of the arteria magna in the region of the loins, and are there for that purpoſe united by a very conſpicuous anaſtomoſis. They riſe out of the trunk of the arteria magna, then they bend *hh* circularly under the lungs; and, after ſending out ſome branches, they likewiſe emit *ii* the axillary arteries from off their ſides. We obſerve, that a little deeper beneath the heart, the carotid arteries ariſe from them; and that theſe aſcending *kk* from thence towards the head, bury

themſelves

themſelves in the bones of the ſkull. The arteries of the vertebræ, alſo ariſe *ll* from theſe branches; and at length uniting together by a manifeſtly conſpicuous anaſtomoſis, they conſtitute the trunk of the loins; out of which riſes the cæliac artery, which afterwards ſends out from it *m*, the meſenteric artery. Some arteries alſo, as thoſe of the loins *nn*, and thoſe that are detached to the teſticles, ovary *oo* and reins *p*, have their origin from the ſame trunk; and this ſame trunk is itſelf afterwards divided in the laſt place into the iliac *qq* branches.

The blood being driven out of the heart through all theſe arteries, to the circumference of the body and viſcera, at laſt returns by a manifeſt circulation through the veins to the heart, as to its center; whilſt in the mean time only a part of it circulates through the lungs, and indeed exactly in the ſame manner in which it circulates through the muſcles and the reſt of the viſcera. Therefore, the blood in the Frog circulates in a quite different order, than is obſerved in other animal quadrupedes, or in fiſhes; in which all the blood paſſes either thro' the lungs, or thro' the gills: that is, the upper trunks of the vena cava, which are united to the auricle of the heart, and are here delineated under both trunks of the great artery, do not in the Frog deduce their blood from the lungs; but they imbibe it directly from theſe veins, which run in the upper part of the body, and from ſome others that are ſituated next to the ſkin in the ſides lower down, and they likewiſe get a ſmall portion, that returns from nouriſhing the lungs. The blood, on its return from the lower parts of the body, does not touch the lungs, but diſcharges itſelf thro' the porta and cava, into the auricle of the heart, without coming near the lungs. Therefore, by inflating only one vein of the Frog's body, the arteries may be all inflated alſo.

The diſtribution of the Veins differs here conſiderably from that of the arteries; for the two trunks of the the cava, are conſpicuous above at the auricle, Tab. XLIX. Fig. IV. *aa*, where I have opened *b*, the arteries, emit pulmonary veins out of their lower ſide, (here cut off) *cc*, which are twice as large as the arteries. Theſe veins are properly placed in the cavity of the lungs, and particularly in the extremities of the pulmonary veſicles, and in the loins; and they diffuſe their capillary, and almoſt inviſible branches all over the cells; nay, even thro' the coat which inveſts them. Here, therefore, in the lungs of the Frog, a conſiſiderable blood-veſſel, namely, the arterial vein, is wanting: the animal has no need of this artificial canal; ſince Nature did not intend that all the blood ſhould paſs thro' the lungs. Beſides, the two upper trunks of the cava paſs above the arteries in the Frog, and are alſo divided into various branches. Some little veins are from thence detached *dd*, to the parts about the mouth: others, which bend very beautifully in their paſſage, go towards the head *ee*, and give a part of themſelves *ff*, to the muſcles of the firſt pair of legs. The axillary veins alſo, ſpring *gg*, from the ſame trunks, and emit two very conſiderable *hh* branches, which in the ilia beautifully bend themſelves back under the ſkin above the muſcles of the belly; and from thence aſcending again towards the thorax, and being there conſiderably dilated, they communicate, by a mutual anaſtomoſis, with the reſt of the veins that are ſituated about theſe places. The trunk of the cava, which is ſituated beneath the heart, is ſimple *i*, and is there divided into three branches, which are diſperſed thro' *kk* the liver. A little lower, the meſenteric vein riſes *l* out of the liver: under which the trunk of the cava very beautifully diffuſes *m* itſelf, by many branches over the kidneys; and at length, after dividing into two parts, conſtitutes the iliac *nn* branches, from which the epigaſtric vein is obſerved to riſe *oo* very beautifully. This vein goes back along the ſtraight muſcles into the liver; where I repreſent it cut off. But if this little veſſel, and all the integuments of the belly, be diſſected near the liver, and then turned above the hind legs; all the veins of the body may be conveniently inflated through it. By this means veins are diſcovered in the liver, the kidneys, and all the viſcera. And from thence I took an opportunity of making, with very little labour, the following very remarkable experiments. Let what hath been hitherto ſaid, ſuffice in regard to the circulation of the blood, and the blood-veſſels in the Frog.

Having finiſhed the obſervations now recited, as quick as poſſible, I afterwards examined ſome muſcles, and alſo the ſkin, eyes, and blood of a full-grown Frog. I found it eaſy to divide the moving fibres of the muſcles ſo ſmall, that they reſembled a Spider's web. But when I put them divided in this manner under the microſcope, I found they conſiſted of ſtill ſmaller fibres, and thoſe of very minute globules. I firſt diſcovered the epidermis in the ſkin; it ſupported the real ſkin, the latter being adorned with beautiful colours and black ſpots, and appearing compoſed, as it were, of globules. I further ſeparated the ſkin into a glandular ſubſtance, which was compoſed of very numerous globular glandules. Thoſe glandules ſecreted that viſcous or ſlimy matter, which is obſerved to be ſpread over the ſurface of the Frog's ſkin, and rendered the latter very ſmooth and ſlippery. This ſpecies of mucous matter taſtes bitter, and offends the eyes with its acrimony; nay, it cauſes a ſenſible pain, if rubbed to our ſkin when wounded a little; ſo that we muſt be cautious in the uſe of it. I next examined the aqueous humour of the eye in a glaſs tube; but I perceived nothing more than the clearneſs of the liquor. And hence, then putting both extremities of that tube to a lamp, I boiled that and the whole Frog's eye in water: but there were no globules conſpicuous in it from this proceſs. Both the white part of the cryſtalline humour, which reſembles chalk, and ſurrounds it, and the other fibrous diaphanous portion, which is divided into ſeveral lamellæ or plates, conſiſted entirely of globules. I ſaw a ſerum in the blood, in which were a vaſt number of orbicular particles, of a flat oval but regular figure. These particles ſeemed alſo to contain another fluid: but when I viewed them ſideways, they reſembled cryſtalline clubs, and ſeveral other figures; that is, according as they were turned about in various directions in the ſerum of the blood. I obſerved beſides, that the colour of objects always appeared the more faint, the more they were magnified with a microſcope.

Experiments on the particular motion of the muſcles in the Frog; which may be alſo, in general, applied to all the motions of the muſcles in Men and Brutes.

HOW important and difficult it is to explain the real cauſes of muſcular motion, is ſufficiently evident from numerous experiments; which though made by very ingenious men, yet have not hitherto diſcovered its true nature. The great utility and foundation of further knowledge, which we ſhould acquire from that diſcovery, lie yet involved in the thickeſt clouds of obſcurity. This is the reaſon which now induces me to publiſh the experiments I made concerning the matter; which, as they ſeem to me to have great weight, and to contain ſome uſeful conſequences, I would therefore adviſe my readers to conſider ſeriouſly, and examine them by the touchſtone of truth.

In the conſtruction and motion of the muſcles, it merits particular conſideration, in what manner the nerve is actually joined to the muſcle; how it is conſtructed in the muſcle; what is its courſe, entrance, middle, diſtribution, and end; as alſo how it communicates with the moving fibre, and what effect it produces in it; alſo what that very ſubtle matter properly is, which is undoubtedly conveyed to the muſcle through the nerve. The knowledge of all theſe particulars is not ſufficient for our purpoſe: one muſt likewiſe know the conſtruction of the membranes, that inveſt both the ſurface of the muſcle and its inward parts, and the delicate leſſer fibres that reach from one moving fibre to the other, and, like a very fine web, diffuſe themſelves through the interſtices of the latter. It would be likewiſe neceſſary to know the ſtructure of the vein and artery belonging to the muſcles, and their real conſtitution or diſpoſition in the muſcle, and to underſtand accurately what belongs to the compoſition of the moving fibres. But all theſe things are ſtill obſcure and unknown, and will not be probably diſcovered till we employ all our time, and the greateſt diligence, in inveſtigating them: but all difficulties are conquered by induſtry, and an unwearied application. As to myſelf, I candidly confeſs, that I have not brought every ſubject, which I have advanced, to the greateſt perfection poſſible; for, in order to attain this, I ſhould have ſpent my whole life in diſcovering one thing, and this courſe is not agreeable to me: for I am thoroughly perſuaded, that, if I came to the utmoſt extremity, I ſhould at laſt diſcover nothing but my own ignorance. For this reaſon, I thought it better to employ my time rather on various things than on one; leſt, whilſt I was too intent on a thorough knowledge of one or two particulars, many of God's work ſhould lie hidden from me: for, indeed, all the knowledge we are capable of, conſiſts only in this, to love God as we ought.

With reſpect therefore to all the ſubjects hitherto recited, I ſtill find many indiſſoluble difficulties. And though the excellent anatomiſt, Dr. Steno, hath diſcovered many curious things relative to this matter, yet he ſtops alſo in the middle of his courſe. Beſides, how far are we from knowing the motion and effect produced by the ſubtle ſpirit, that continually paſſes through the nerves into the muſcles! This matter lies buried in impenetrable darkneſs. Since I have made many experiments, at different times, on the motion of the muſcles, I ſhall now, however, ſet forth the chief of them, and ſubmit them to the examination of the learned.

It is a matter eternally certain, and of greateſt moment, that whenever the nerves of living bodies are handled, there is immediately obſerved a conſiderable motion in the muſcles to which they are ſent, and this motion does not at all differ from the contraction of thoſe muſcles. If we lightly pinch or prick the nerves of the diaphragm in a living dog, opened for the experiment, with the point of a very fine needle; or if we ſtimulate them by putting them near the fire, or by pouring acrid liquors into them; we immediately ſee the diaphragm performs its natural function: it contracts itſelf, from being arched becomes ſmooth, raiſes itſelf from the thorax, puſhes out the viſcera of the abdomen, and the cavity of the thorax is enlarged in proportion as the diaphragm contracts itſelf and becomes more ſmooth, and is more ſtretched out of the breaſt.

This experiment is very fine and elegant, ſince the motion alſo, which is then obſerved in that compound muſcle, appears admirable; and the ſame experiment may be often repeated in the ſame ſubject, if the nerves of the diaphragm be firſt irritated, where their beginnings run near the pericardium. In order to irritate them a ſecond, third, and fourth time, we muſt deſcend by degrees, and chooſe a lower part of them, until we come to the very place where they are inſerted in the diaphragm.

This experiment on the nerve may alſo be very eaſily made, not only in this but all the other muſcular parts of the animal's body, with the ſame ſucceſs. Hence we often obſerve, on diſſecting living animals, that when the nerves are wounded with a knife, conſiderable motions ariſe in the muſcles to which they belong. This the celebrated Steno hath likewiſe obſerved in his Myolog. Specim. p. 78 and 79, after I had ſhewn him my old and common experiment on Frogs. This is obſerved to happen

happen not only in quadrupedes, but in birds and fifhes, but efpecially in the Wray-fifh; in the mufcles of which there are very ftrong motions, when the nerves are irritated.

On the foundation of thefe motions, which are produced in the mufcles, when their nerves are only difturbed or ftimulated, I determined to provoke the nerves of the entrails in the fame manner, in which I found very remarkable flefhy fibres. I had a mind to make the fame experiments on thofe nerves which reach to the kidneys, liver, fpleen, lungs, and genital organs; for I would fcarce prefume to affirm, that any remarkable contractions are produced in thofe parts, efpecially in the kidneys, by fuch irritation; and therefore one may penetrate much deeper, by that experiment, into the real ufes of thefe parts. But I have not yet been able to execute my purpofe, for want of time. It is therefore fufficient for me here to have hinted at thefe things in a few words, that others may have an opportunity of labouring further in the difquifition of them; for Nature muft be inveftigated by the joint labours of many. One man can make no great advancement in matters infinite.

I beg leave to obferve here, that the motions of the mufcles, now mentioned, are not fo confiderable in animals which have warm blood, or rather they do not laft fo long, as in thofe that have the blood cold; as fifh, and many other aquatic creatures, which have few or no feet, and in amphibious creatures in general. Hence I chiefly made my experiments on the Frog; for the nerves are very confpicuous in thefe animals, and may be eafily difcovered and laid bare. The fpinal marrow and the brain have this peculiarity in the Frog, that, like a fluid falt, they lie enclofed in coats, and, being interwoven with blood-veffels, are every where adjacent to them; fo that they are to be difcovered plainly even in the cavity of the vertebræ, and in the fkull. The fpinal marrow glitters like pearl, and is difpofed, in the form of knots, all down the back, along the vertebræ, where it appears very confpicuous. This native falt, mixed with an acid liquor, ferments very ftrongly. Its fubftance anfwers very nearly to that granulated and gravelly powder found in the head of the Shark, and fold in the fhops, and erroneoufly taken by the ignorant, for the brain of the fifh; but this is nothing more than a ftony and gravelly fubftance, which is placed in the head of the Shark, as what is called the Perch-ftone is in the head of the Perch. I have likewife found fuch a powder in the Wray-fifh's head, which fermented very ftrongly with an acid: and, therefore, I think that the alcaline falt, obfervable in the little ftones called Crabs-eyes, is like this. But though that faline fubftance in Frogs is fluid, like water, it will notwithftanding be dried immediately by the heat of the hand or fingers; but it never hardens to fuch a degree, but it may be very eafily reduced to fine powder with the tips of the fingers. The fame thing likewife holds with refpect to that calcarious fluid matter in the Wray-fifh. Whether this falt has any medicinal virtue, I cannot yet fay; nor can it be known, except from experience. I return to the mufcles.

Another very delicate and ufeful experiment may be made, if one of the largeft mufcles be feparated from the thigh of a Frog, and, together with its adherent nerve, prepared in fuch a manner as to remain unhurt. For if, after this, you take hold, Tab. XLIX. Fig. V. *a a*, of each tendon with you hand, and then irritate *b* the propending nerve with fciffors, or any other inftrument, the mufcle will recover its former motion, which it had loft. You will fee that it is immediately contracted, and draws together, as it were, both the hands, which hold the tendons. This I formerly (in the year 1658) demonftrated to the moft illuftrious the now reigning Grand Duke of Tufcany, when he gracioufly vouchfafed to pay me a vifit. This experiment may be repeated in the fame mufcle, as long as any part of the nerve remains unhurt; and we can thus make the mufcle contract itfelf, as often as we pleafe.

If we have a mind to obferve, very exactly, in what degree the mufcle thickens in its contraction, and how far its tendons approach toward each other, we muft put the mufcle into a glafs tube, Fig. VI. *a*, and run two fine needles *b b* through both its tendons, where they had been before held by the fingers; and then fix the points of thofe needles, neither too loofe nor too firmly, in a piece of cork. If afterwards you irritate, Tab. XLIX. Fig. VI. *c*, the nerves, you will fee the mufcle drawing *d d* the heads of the needles together out of the places; and that the belly of the mufcle itfelf becomes confiderably thicker *e* in the cavity of the glafs tube, and ftops up the whole tube, after expelling the air. This continues till the contraction ceafes, and the needles then move back into their former places; and the belly of the mufcle, parting again from the tube, affords a free paffage for the air through its cavity. But if the mufcle be left to itfelf, or put into cold water, with all the apparatus juft now defcribed, we obferve it contracts itfelf by degrees not long after; and is finally fo remarkably bent, as to fill the whole cavity of the middle region of the tube.

Having therefore duly confidered thofe experiments, which I have hitherto fet forth, and at the fame time attentively weighed the force of contraction or mufcular motion, which the mufcle refumes every moment, when its nerve is again and again irritated: one may afk, whether any other communication be neceffary between the nerve and the mufcle, but only that fimple irritation on the touch or commotion? But as a fimilar motion is likewife excited in the mufcles of animals which have hot blood, whofe nerves are ftimulated; the fame queftion indeed may be likewife afked here, that is, whether in this clafs of animals alfo, any other communication be neceffary between the brain and marrow, the nerves and

and mufcles, except this ftimulus? for I have conftantly found, by all the experiments that I made, that the mufcles are contracted when the beginning of the marrow, or the nerves iffuing from thence, are moved.

Hence I propofe it, as a matter worth confidering, whether we fhould not reject that opinion, which fuppofes a fpirituous matter to be neceffary to excite mufcular motion, and that it flows out of the brain; and that this influx happens with fuch great rapidity and velocity, that thefe new fpirits conftantly propel the former, and in an inftant of time, at the leaft intimation of the will, or otherwife fpontaneoufly fhould, and may, be in the moft remote extremes of the body.

I am perfuaded, thofe who derive the contraction of the mufcles from inflation, fermentation, or a kind of explofive motion, will differ from me as to this matter: they will object, that the inflation or expanfion of the moving fibres, is evident even to the eyes, in the contraction of the mufcles; and befides, that all the mufcular parts are filled with fpirits: and therefore, that only a fmall quantity of animal fpirits is requifite to inflate either thefe, or thofe mufcles, and to expand them by contraction, as is evident to the fight.

But all thefe opinions are certainly deftroyed, if it be confidered, how often the motion of each mufcle is reftored by only ftimulating, provoking, or irritating the nerve in my experiment before mentioned: and this, when the nerve hath been for a long time cut off, and the requifite animal fpirits diffipated, or grown weak, after many times difcharging their duty; and when there is no further communication between the nerve, brain, and marrow. Therefore, I would have it ferioufly confidered, that it cannot be demonftrated by any experiments, that any matter of fenfible or comprehenfible bulk flows through the nerves into the mufcles. Nor does any thing elfe pafs through the nerves to the mufcles: all is a very quick kind of motion, which is indeed fo rapid, that it may be properly called inftantaneous. Therefore the fpirit, as it is called, or that fubtile matter, which flies in an inftant through the nerves into the mufcles, may with the greateft propriety be compared to that moft fwift motion, which, when one extremity of a long beam or board is ftruck with the finger, runs with fuch velocity along the wood, that it is perceived almoft at the fame inftant at the other end; nay, that it is further propagated through the nerves into our mufcles; and thus produces various motions in them, as thofe who attentively confider this fingular, though plain experiment, well know.

Add to thefe another argument of yet greater weight, which is, that the mufcles themfelves, when contracting, are not in the leaft inflated or fwollen, but rather they lofe their thicknefs; though the moving fibres in the mean time acquire a different fituation; or, to exprefs the matter more exactly, they are preffed clofer to each other. We obferve fomething like this in a long piece of fpunge, made even and fmooth, which becomes thicker and more folid by force of compreffion; though in reality it poffeffes a much lefs fpace. Therefore, for the many reafons which fhall be mentioned hereafter, I think it may be rightly inferred, that the fhortening and clofer compaction of the moving fibres, by reafon whereof they are contracted into a lefs fpace, is really the true action or contraction of the mufcle; and which is therefore erroneoufly called inflation, tumefaction, &c.

For what reafon can any one imagine it poffible for the mufcle to be inflated? fince it confifts of fuch fubtile filaments, as are almoft invifible; though even thefe are finally compofed of globules. What matter can effect this inflation? Is it not neceffary, that it fhould pafs through thofe very fine fibrillæ, which conftitute the nerves, and when curioufly examined, without hurting them, are likewife fo fmall as to be almoft invifible? Certainly, if the nerves be confidered to have their origin from the marrow, it is very evident, that they are fo fubtile there, and fo clofely furrounded by the meninges, that the fmalleft briftle, or thread of fpun glafs, can fcarce pafs through the aperture. How fine therefore muft that fpirit be, which can penetrate into this very cavity, which is likewife ftopt up by the nervous filament that iffues out of, and is contained in, it? Yet authors eftablifh fuch notions; nay, they proceed fo far, as to imagine, that the nutritious matter, to which fome attribute the thicknefs of the white of an egg, paffes through thefe very nerves: but this opinion is fo idle and abfurd, that it does not deferve a ferious refutation. In the fame light I confider the imaginary fermentation between the fpirits and blood, by which the mufcle is faid to be inflated; though the very method of this inflation is contrary to the known conftruction of the mufcles.

Another thing that plainly contradicts the inflation and influx of the fuppofed fpirit into the mufcles, is that we clearly fee, tho' the mufcle be cut, and its moving fibres feparated from each other, all thefe parts move again, as it were naturally, as foon as the nerve which belongs to them is irritated: and this experiment, as well as others, may be made on the Frog, and feveral other water-animals, and it fucceeds very particularly in the Duck.

From thefe experiments therefore, it may, I think, be fairly concluded, that a fimple and natural motion or irritation of the nerves alone is neceffary to produce mufcular motion, whether it has its origin in the brain, or in the marrow, or elfewhere.

Therefore, we likewife obferve in many animals, that as foon as the beginning of the fpinal marrow is moved in the brain, all the fubjacent mufcles are fuddenly contracted. And this happens in the fame manner with refpect to all thofe branches of the nerves which arife out of the marrow, at leaft whilft they are handled; tho' only fome of the mufcles, or perhaps that only, through which the irritated nerve is diftributed, are put in motion. We muft alfo take particular notice, that in this experiment, it is never obferved,

ferved, that the part of the nerve above the irritated region, contract alfo thofe higher mufcles, that have their nerves from thence. We very clearly find alfo by experiments, that the motion produced in the mufcle by irritating the nerve, is always propagated out of the larger into the fmaller branches, and goes afterwards continually defcending. The nerves defigned for the fenfes are circumftanced in a quite different manner; for in thefe, the fenfitive motions, doubtlefs, tend upwards. In order to contract any mufcle, it is neceffary that its nerve be irritated in the region above the mufcle, or at its infertion into it; fince that motion never tends upwards, but always downwards.

It may now be probably afked, wherein I think the beginning of that natural irritation, ftimulus or provocation of the motion, thus communicated to the mufcles through the nerves, confifts? Since I deny, that any vifible flowing and inflating fpirits, are locally moved through the nerves; and, on the contrary, think that a certain inftantaneous irritation is much more fubtile, and capable of the effort, than the fpirits fuppofed by fome neceffary to move the mufcles: and that, from thence, it follows, that this irritation fhould not only have its origin elfewhere, but that a force is likewife wanting, by which that motion is transferred through the nerves into the mufcles. I confefs thefe things are requifite, fince experience demonftrates it even to the eye.

To give a proper anfwer to this queftion, I think, the beginning or principle of that motion lies in the fpinal marrow, and is alfo in all the nerves of the body; fo that the marrow, and all the nerves, are conftantly and perpetually irritated to give motion to every mufcle of the whole body. I would have it particularly obferved, that I admit no effential difference between the natural and fpontaneous contraction of the mufcles, and that performed by the will. I confider this difference as merely accidental; but, becaufe we move all thefe mufcles, which we move voluntarily, in a contrary direction; that what is faid to be effential in the contraction of all mufcles, is a natural contraction. For this reafon, voluntary motion ceafes, or is changed in us, as well as in all other animals; when either the antagonift mufcles are wanting, or when one of a pair is more powerful than the other, as I have formerly demonftrated in my treatife on Refpiration. And indeed we cannot move mufcles at will, unlefs we have the power of determining the natural motion of the antagonifts to the contrary fide. But if all the motions of our mufcles are continual and natural, when the antagonifts are wanting, as is the cafe with refpect to many mufcular parts of our body, which we have not power to move at our pleafure; only fo far as thofe mufcles are firft dilated by their contents. Thefe perform the office of antagonift mufcles, and give us the power of moving them in a contrary direction at the command of our will:- but otherwife, all things acquiefce in the perpetual contraction.

In order further to explain the origin of this natural and perpetual contraction of the mufcles; I think indeed it arifes from the continual impulfe of the arterial blood upon the marrow and nerves: for, by means of this blood, all thofe parts feem to be continually moved, excited, and irritated to convey that motion pepetually and uniformly to the mufcles, and to prepare the latter for their perpetual contraction. For this reafon, all the nerves without exception, have not fewer arteries in proportion, than the brain itfelf, and the fpinal marrow have. I fhould think indeed, that this matter might be eafily afcertained by experiments: for which purpofe, I once thought of injecting a peculiar liquid through an artery into the marrow, by a fmall fiphon, and then to obferve carefully, whether any motion was thereby excited in the mufcles. But I would again advife the reader, to confider well that wonderful motion and power of the mufcle, when its nerve is in the leaft difturbed or ftimulated.

It is now time to proceed further; and I fhall, by a curious experiment, demonftrate to the eye, that the mufcle is not at all fwollen in its contraction, or becomes thicker by inflating it, and therefore occupies the larger fpace; nay, on the contrary, that its fwelling decreafes: and therefore, in its contraction or action, fills lefs fpace than when it refts flaccid. I fay refts, becaufe I cannot obferve that the mufcle in the living animal, ever abfolutely ceafes from all motion. And therefore it fhould be rather faid, that it is lefs ftrongly moved at the time of its relaxation; or then only recollects its elaftic ftrength, that it may be able, the moment after, to make the ftronger effort to contract itfelf. This may be feen very clearly in regard to the motion of the heart and auricle in the Frog; for the blood is there brought back from the circumference of the body, according to the laws of circulation, and being driven in to the auricle, it may be confidered as the auricle's antagonift mufcle, which dilates it: but the auricle itfelf is the antagonift of the heart, fince by means of the blood, which it protrudes into its cavity, it likewife dilates its fubftance, fo that the wonderful, repeated, and continual pulfe of the heart, has its origin from this alone: that pulfe is therefore perfectly natural and neceffary; for thofe two mufcles, that is, the heart, and its auricle, are unequal in fize and ftrength, and therefore their motion is neceffarily varied. If the auricle were as firm and as ftrong as the heart, the motion of each would abfolutely ceafe; for, wherever the power of the antagonift is equal, there is obferved no motion of the mufcles, and all things are in both in equilibrio, until there arifes another determination, which, caufing one mufcle, to be contracted fomewhat more ftrongly than another, at length moves our limbs. Such a determination may proceed from various caufes.

If, for example, a man's fkin be very gently rubbed and irritated with a hair doubled feveral times; I often obferved, that the motion of the antagonift mufcles of the arm and hand was immediately determined; fo that the perfon inftantaneoufly, as it were, unknown to him; has put his hand to the place where he felt the titillation,

 and

and then fcratched the fkin until he made it red, imagining that it was probably occafioned by a Flea, or fome other infect. But when I ftopt, his hand and arm refted likewife, becaufe the natural contraction was then equal in all the mufcles. If the fame experiment be made on fleeping dogs or cats, it is likewife obferved, that a determinate motion is produced in the mufcles which move their fkin; and therefore it is pleafant to fee them fuddenly draw it up, pricking up their hairs, and fometimes fkaking them in their fleep. By this familiar inftance, it is evident how our mufcles are in like manner voluntarily moved without any great attention of the will, by fomething of this kind, which is proper to determine the natural motion of the antagonift to the contrary fide.

Now, in order to make it certain from experiment, that the mufcle is not inflated in its contraction, but on the contrary poffeffes lefs fpace, we are to take a very lively and found Frog, and diffect it, uncover its heart, and carefully take away the pericardium from it. After this, we muft choofe one or two veins or arteries, which are large enough to be conveniently opened, and to admit a thin glafs tube. By this tube, all the veins and arteries of the body, and confequently the heart, may be very eafily inflated; fince, as I have before hinted, the lungs are in this animal no obftacle.

When the heart is filled with air, it muft be dexteroufly, together with its auricle, tied with a fine thread, and cut away from the body: then let a glafs fiphon be ready, one end of which muft be a narrow and fmall tube. Let the heart thus inflated, and its auricle, be put into the flat end of this tube, and let all be immediately put into that glafs fiphon; the long tube of which muft, in the mean time, be ftopt with a very fmall drop of pure water, or, that it may be the better diftinguifhed, water coloured with blood.

Having duly obferved thefe directions, it will manifeftly appear, that at the time the heart, Tab. XLIX. Fig. VII. *a*, contracts itfelf within the little fiphon, *b b*, the drop of water adhering near the extremity of the tube, *c*, defcends in a very remarkable and furprifing manner to the other end of the tube, *d*, where it fprings from the fiphon; and, on the contrary, it will likewife diftinctly be feen, that the drop thus fallen down, *d*, will, on the heart's dilating itfelf again, rife to its former fituation, *c*.

This experiment furnifhes us with an evident proof, that when the mufcle of the heart contracts itfelf, not only all the fibres which ferve to move it, are preffed clofer to each other, but that the heart itfelf alfo, occupies a fmaller fpace in its fyftole, than it did before in its diaftole.

This alfo is the reafon why the drop of water *c* moves downwards, *d*, as it cannot but follow the heart, when this contracts itfelf. But if at the very inftant of the heart's contraction, any inflation, tumefaction, or dilatation, had been produced by the animal fpirits on the infide of this organ, the drops, inftead of defcending towards the belly of the fiphon, *d*, would infallibly have rifen towards the extremity of the tube, *e*.

As the former never happens; and the latter, the very reverfe of it, is conftantly the cafe, I may fairly and plainly conclude, that the mufcle of the heart requires lefs room by a great deal in its contracted, than in its dilated ftate; and that hence the fuppofed fpirits, by which it has been hitherto believed, that the heart, or its mufcle was puffed up at the time of its fyftole, has not the leaft fhare in producing that effect.

Moreover, if we open a living Frog, and carefully attend to the motion of its heart and the auricle, we fhall find, that in this experiment, every thing proceeds exactly in the fame manner as it did in the former. For, when the auricle contracts itfelf, it very fenfibly grows fmaller, and more compact,; but when the heart is again contracted, it undergoes the fame alteration; and this obfervation is fufficient to convince us, that there is no manner of difference between the two contractions of the heart, one of which takes place within the fiphon, and the other naturally, except that the heart, out of the fiphon, is inflated with blood, and with air in the fiphon.

As to the other experiment made in the fiphon, we muft here particularly obferve, what happens in the heart during its dilatation, and what change is feen afterwards during its contraction. When the heart dilates itfelf, we plainly perceive that the auricle begins firft to contract, and while it does this, the air is forced from it into the heart; by which means it is confiderably expanded, and appears in the fiphon as if full of bubbles or bladders of air. It even becomes pale and tranfparent on this occafion, and appears irregularly affected. This is owing to its moving fibres, and flefhy columns, not being every where of the fame thicknefs, fo that fome of the parts of the heart lying between thefe columns, are more diftended by the impelled air than others. Thus at length is effected, the afcent of the drop of water adhering to the glafs tube.

When the moving fibres of the heart again contract themfelves, we obferve that the heart draws itfelf in, and becomes fmaller, and immediately after, we fee the air forced from it, in its turn into the heart; upon which this laft immediately becomes more red and opaque, and fhrinks up fo as to put on an unequal appearance: but as the heart at this time cannot return to the auricle, all the air it had thence received, its moving fibres approach towards each other with fo violent an effort, that they likewife condenfe the air contained in them: and thus is the drop of water adhering to the tube of the glafs fiphon preffed downwards, on account of the heart being then reduced to a lefs fize.

This is likewife the cafe with the heart, which is naturally full of blood; for when this organ in its fyftole is diftended by the blood, it draws away the circumambient air; but when it again contracts itfelf, and difcharges its blood, it grows lefs, and yields to the air in proportion as it fhrinks up, a thing which ought to be well attended

tended to, as it is very confpicuous in a living animal. The blood itfelf undergoes fome condenfation, when violently compreffed by the contraction of the heart, and forcibly expelled out of it; but is alfo on the other hand fomewhat rarified, when the heart is dilated by a new intromiffion of blood, fo that this natural action of the heart and blood correfponds exactly with that artificial one of the heart and air in the foregoing experiment.

It may be objected, that naturally in the live animal, the air by no means approaches the heart, and therefore cannot be repelled by it. But the contrary is plain in the cafe of Tadpoles, in which we fee the external fkin fenfibly affected by the pulfations of the heart, and fwell out and fink in alternately, as that organ dilates or contracts itfelf, which is the fame as if the air preffed immediately againft the heart itfelf. It cannot be denied, but that the fame thing muft happen in all animals that have lungs and gills, and a moveable breaft; nay, it muft, without doubt, take place in fome motions of the mufcles.

If you cut a Frog's heart out of the body, and place it in the glafs fiphon, in the manner before defcribed, without firft blowing it up; you will plainly fee the drop of water move in the fame way it did before, though not fo much as if the experiment were made with an inflated heart. In the mean time, the water alfo will fink in like manner, when the heart contracts itfelf. Experience teaches us, that the defcent of the drop of water in this experiment becomes fometimes fo inconfiderable, that it cannot be perceived, even by the help of the microfcope, which is owing to this, that the heart then continues partly contracted, and is not dilated by the auricle, which is now become infufficient to produce that effect, as it neither propels any blood, or air, with which the heart could be diftended. Hence, of courfe, the contraction of the heart muft become proportionally weaker, and the motion of the water in proportion lefs difcernible. But if you blow into the auricles at this time, that this auricle, by contracting itfelf, may force a quantity of air into the heart; the fuccefs of the experiment will immediately become much more confpicuous.

If, inftead of the heart, we fhould chufe to make ufe of fome other mufcle, we may proceed in the manner reprefented in the eighth figure, where the glafs fiphon, Tab. XLIX. Fig. VIII. *a*, contains within its hollow the mufcle, *b*, and the nerve hanging from the mufcle is faftened, without being cut or bruifed to a flender twifted filver wire, *c c*, that runs at the other end, an eye made in a piece of brafs wire, foldered to the embolus or pifton of the fiphon, *d*. Things being thus made ready, a drop of water, *e*, muft be let into the flender tube of the fiphon by a very fine funnel. Now, if after this, the filver wire be cautioufly drawn with a liefurely hand *f* through the ring or eye of the brafs wire, till the nerve is irritated by the compreffion, it muft by this means undergo, the mufcle will contract itfelf in the fame manner with the inflated heart, whofe alterations, upon a fimilar occafion, I have already defcribed, even the drop of water will in fome meafure fink, though afterwards it never rifes again. But this experiment is very difficultly fenfible, and requires fo many conditions to be exactly performed, that it muft be tedious to make it; for which reafon, I have bethought myfelf of another that may be more eafily underftood and performed.

You muft have ready a little glafs fiphon, Tab. XLIX. Fig. IX. *a*, cut through with a diamond near the extremity of its flender tube, *b*; then pafs through the hole thus made, the nerve of the mufcle *c*: but as the air can eafily make its way through this hole, while the nerve is irritated, till it contracts itfelf, fo as to keep the water from finking; it is abfolutely neceffary to ftop that paffage on the outfide, which may be eafily done with a little ifing-glafs and ftarch. But I muft own, that in this experiment, the finking of the drop is fo inconfiderable, that it can fcarce be perceived: for this reafon, the heart is fitter for this experiment than any other mufcle, as it continues and keeps up for a confiderably long time, and with fufficient ftrength, the motion it has once received.

There are fufficient reafons why this experiment fhould fucceed better when tried upon the heart, than upon the other mufcles; the principal feems to be this, that in the other mufcles, there is no antagonift to dilate them externally, nor any blood, which introduced into the bloodveffels, can extend them, and difpand the mufcle itfelf from withinfide; though all thefe conditions are abfolutely neceffary to affect a perfect contraction in any mufcle.

The experiments which were fome time ago publifhed with a view of proving, that a quantity of blood is requifite to contract the mufcles, do in reality no fuch thing. Their principal weight lies in the conftriction of the aorta, effected after D. Steno's method; but this is truly nothing to the purpofe, and can only impofe, at firft fight, even upon thofe who examine matters of this kind with the leaft circumfpection. For, by only confidering with a fmall degree of attention, that the vertebræ, many nerves, and even the fpinal marrow, which are all faftened by the ligament, directed by D. Steno, to be ufed on this occafion, undergo thereby a violent compreffion, it muft plainly appear, that no conclufions can be fairly drawn from fuch a trial. Much lefs can we infer any thing from the other experiment, in which the blood is expelled from the mufcles, to make room for water introduced into them by a fiphon; fince the moving fibres of the mufcle are confiderably injured by this rough procedure; fo that this coarfe experiment can only fupport a weak argument with unthinking people, being calculated merely to confirm the experiment of D. Steno juft now defcribed. Stronger proofs may be reafonably infifted upon, to demonftrate a thing of fuch importance, and the ligatures of the arteries of the thigh, particularly, in Frogs, muft be allowed to be a great deal more to the purpofe.

We ought, however, greatly to commend D. Steno's circumfpection, in not taking upon him-

himfelf to determine the manner in which the motion of the mufcles is performed; neither was he bold enough to pronounce, for certain, that this motion proceeded from the influx or afflux of any new matter. But after I had, fome years ago, made him acquainted with the experiments I had made on this occafion, as already related, he made no difficulty of telling me plainly, that he was in no meafure afraid of abfolutely denying the acceffion of any new matter in the contraction of the mufcles; fo that our opinions of this important operation perfectly coincide.

Even I myfelf, relying on the propriety and certainty of the experiments I have propofed, can now, without any difficulty, maintain, that a mufcle, at the time of its contraction, undergoes no inflation or tumefaction, from the afflux or effervefcence of the fuppofed animal fpirits; but that, on the contrary, it in this ftate becomes fmaller, or collapfes; or, to exprefs my meaning more clearly, it takes up lefs room than it did before.

Nothing can be more evident than this alteration, when a heart filled with air inftead of blood, or one quite emptied, is made ufe of; in the firft of thefe experiments, there occur many other things worth our notice, which may all have place and force in the contraction of the mufcles: firft the enclofed air in the heart is condenfed, and forced together; fecondly, the circumambient air is dilated; thirdly, the fibres of the heart are moft violently compreffed and ftrained in this action, and the little cavities within, or between them, are compreffed; fo that whatever has lain in thefe cavities muft be difcharged. And all thefe things appear chiefly at the time the heart relaxes, as it were for a moment in its contraction: fourthly, the internal air is afterwards again rarified in the heart: fifthly, the external air is on the contrary condenfed, and driven from its place: and fixthly, the fibres of the heart are again extended or dilated.

If any one object, that the air in this cafe is out of the courfe of Nature in its place, I can readily anfwer, by affuring him, that I have found air in the hearts of human fubjects, opened immediately after their death. But as this is not a common cafe, I am content, that blood may be fubftituted to the air which I fuppofed to be found in the heart: the blood contained in the cavity of the heart, is on that cavity's contracting, fhaken, condenfed, and expelled; the fame thing alfo happens to the blood which then flows through the coronary veins of the heart, and fhaken, or violently driven out of them; upon which account alfo, the fubftance of the heart grows confiderably paler at this particular time. Now, while the heart is thus contracted in its fubftance, the circumambient air is likewife rarified; and laftly, the fibres which ferve to move the heart violently, become powerfully contracted in the fame manner with the inflated heart, as already mentioned. But the laft appearances I took notice of on the fame occafion, and which were the reverfe of the firft, deferve to be here likewife confidered, as they act in the enfuing dilatation of the heart, when in its natural fituation, and when it is moved in its natural manner.

From all thefe particulars it evidently appears, that there occur in the contraction of the mufcles, a great many more things to exercife our reafoning and induftry, than authors have hitherto confidered. And above all, we ought moft carefully to obferve, with what ftrength the moving fibres of the mufcles draw themfelves up while the fibres are contracted. This power is fo great, that I have feen them in fome animals become three times fmaller than in their natural ftate of conftant contraction. And on this account, all their contents, being all the blood and juices which had flowed into the blood-veffels running through them, were moft violently forced out by this powerful motion. Hence alfo it happens, that the mufcle of an animal, whofe blood is red, is much paler in a contracted, than in an expanded ftate. This D. Steno likewife has obferved.

By this obfervation we are enabled alfo to account for the confiderable heat caufed in the body by the determinate and reiterated motion of the mufcles. For as the mufcles propel the blood from themfelves by their violent contractions, it is impoffible the motion and circulation of the mafs of blood fhould not be thereby confiderably increafed; a circumftance which furgeons, who are informed of it merely by experience, have contrived in bloodletting, to take proper advantage of it; for at this time they give the patient a cafe of inftruments, or fomething of that kind, to employ his hands, that the mufcles being thus put in motion, the blood may more freely iffue from the veins: the imagination alone is often powerful enough to have the fame effect, as our mufcles are at that time varioufly influenced according to the lively or gloomy nature of the thoughts which then poffefs us, and proportionably contract and fhut, or expand our hearts.

I faw myfelf, in the hofpital of Leyden, a boy from whofe feet the fkin and flefh had lately fallen off in a gangrene, who by the bare motion of his mufcles, without retaining his breath, could contrive to difcharge at will a confiderable quantity of blood from the wounded part. And I have likewife obferved the fame in the motion of many animals, whofe blood, tho' they wanted lungs, flowed much more freely from them in motion, than when at reft.

This cafe even extends fo far, as to account for laffitude or wearinefs itfelf, which is occafioned by the mufcles being too much diftended by blood, and confequently rendered lefs fit for contraction, as I firft obferved, in fhaping with my breath a piece of glafs melted with a lamp heat; for the mufcles called Buccenatores in my face, came at laft to be fo violently diftended

tended with blood by this operation, that entirely loſt the power of contracting them again, ſo as to be able to diſcharge the air at my mouth, in a manner requiſite for the buſineſs I was about.

It is very wonderful, how inſects in winter, when all their blood and humours are congealed, as it were, in their veſſels, loſe likewiſe all power over their muſcles; ſo that if their legs and other limbs be extended without doing them violence, they will remain in that poſture till the creature recovers the power of moving them, on the return of warm weather, or by being placed near a fire; for a very ſmall degree of warmth communicated to them in the beſt manner, is ſufficient to reſtore them to life and motion, to enable them to turn about, run, and even fly, till their blood and humours congeal again, which they do in a very ſhort time; and the little animal is thereby reduced to its former ſtate of inaction. I have likewiſe obſerved that famous vegetable called the Senſitive plant, is much leſs ſenſible in autumn, than in the ſummer ſeaſon.

It may be aſked how is the effect of the natural determinate irritation of the nerves, or even of that which is produced from without, and by art produced; ſince it is not poſſible to prove, or reaſonable to ſuppoſe, that any ſenſible matter is at that time conveyed, or locally carried into the muſcle; but, on the contrary, it muſt be allowed, that the muſcle diſcharges the matter it contained, ſo as to fill a leſs compaſs?

I muſt confeſs it a very difficult taſk to anſwer this queſtion, and perhaps impoſſible, till the true contraction of the muſcles ſhall be exactly known. For this reaſon I ſhall enter upon a method for attaining ſome certainty in this matter, like that purſued in acquiring juſt notions concerning the uſe of the eye; for the manner in which viſion is performed, was diſcovered without any true knowledge of the ſtructure of that curious organ, by which we enjoy that great bleſſing. Hence, were I permitted to make uſe of a coarſe ſimilitude, I might conceive it effected in the ſame manner with the alterations viſible on handling, or touching ever ſo gently the parts of the Herba Impatiens, called Touch me not, or podded Ars Smart, orthe Balſamita alteria of Fabius Columna; the parts of which plant being extended according to the courſe of two or three nervous or herbaceous fibres, in conſequence of any momentarry irritation, moſt ſuddenly contract, and the pods burſt.* And certainly, if theſe fibres, which cannot ſo expeditiouſly contract themſelves, before the ſeed of the plant to which they belong has arrived at its due maturity, did not curl up and fall off, but inſtead of thus periſhing, could be again dilated like leather, when forcibly bent, and excited by a new irritation to a new contraction, we ſhould have in them a moſt curious example of the action of the muſcles, the principal of which conſiſts in a contraction following a dilatation; ſo that it is the contraction of the muſcles, and not the dilatation of them, that we ought to conſider as their principal office, ſince even when the animal is dead, they will ſtill endeavour to contract themſelves. I have even ſeen a muſcle contract itſelf, when boiled in the ſame balſam in which I had preſerved it for ſeveral years.

Let people think what they pleaſe of the above-mentioned ſimilitude, or compariſon; at leaſt the experiment informing us that the muſcle contracts itſelf as ſoon as its nerve, is put in motion, reſts upon a moſt ſolid foundation: but as I demonſtrated at the ſame time, that a muſcle takes up leſs room in its contracted, than in its dilated, ſtate, it moſt evidently follows, that there does not flow into it at that time, as has been ſuppoſed, any expanding or rarefying matter, but that that ſubſtance muſt be inconceivably fine and delicate, which at that moment of time can produce in the muſcle ſo wonderful a motion; though we are not certain that this effect differs in any thing from that which the wind, a finger, a ſtick, or a briſtle, has in contracting the little fibres in the contractile pod of the Touch me not plant.

I therefore think, that, as I ſaid before, it may be from hence fairly inferred, that whenever the nerve is immediately irritated, the muſcle, to which it belongs, muſt be in a ſtate of perpetual contraction, or at leaſt in a ſtate of perpetual effort, and endeavour to contraction. This is a circumſtance, which I formerly obſerved in my treatiſe of Reſpiration, and ſhall hereafter more clearly explain, as I intend to publiſh a new method, in which we may in ſome meaſure conſider the conſtant motions of the muſcles.

But before I undertake this taſk, and thereby make an end of the preſent treatiſe, I muſt conſider in what ſtate or condition the muſcles were before they exerciſed any motion. This may be very eaſily ſeen in inſects, and even in the rudiments of the muſcles belonging to larger animals, whoſe muſcles at that time are generally compact, white, membranaceous, and ſeem compoſed at their very firſt appearance of a kind of glutinous humour. In inſects, it is very remarkable, that at the time of their changes, their muſcles become in a manner inviſible, and afterwards increaſe in ſize to a prodigious degree; nay, even their limbs diſappear, and grŏw in the ſame manner, but more

* To the plants here mentioned by Swammerdan, may be added ſeveral others, in the ſeed-veſſels of which there is this elaſtick power, which he ſuppoſes in ſome degree analagous to the muſcular motion in animals: in the multitude of examples, the truth will be beſt diſcovered.

The Wood-ſorrel, wild Cucumber, and Lady-ſmock, among the common kinds; and in the Momerdica, Phylanthus, Euphorbiæ, Juſticiæ, Ruelliæ, Dictamnus, Ricinus, Tragica, Jatroplia, Cretan, Çlulia, and Realypha, among the more rare; and moſt of all in the Hura, or Sand Box-tree, which burſts with the report of a piſtol, and ſcatters its ſeparated parts throughout.

Theſe are the ſubjects in which the origin and cauſes of this motion in vegetable parts may be traced, and the ſubject is worthy a full diſquiſition.

particularly their legs, and the mufcles of thofe parts, which fwell and extend every way in a furprifing manner, by means of the blood and humours driven into them, juft as if they had been injected with additional liquors; fo that in courfe of time, they are as it were unnaturally ftretched, and bent in the manner of a bow. But this alteration obtains chiefly in infects, whofe mufcles alfo move much longer than thofe of any other fpecies of animals; and even retain their motion, in many fpecies, after the head has been feparated from the body. We obferve alfo, that as foon as infects break from their old fkins, their bodies grow larger every way, almoft inftantaneoufly; and the fame thing happens, in proportion, to animals whofe blood has an extraordinary degree of heat in it. Hence it is, that their mufcles endeavour the more violently to contract and draw themfelves together. In fine, we likewife very plainly fee that the mufcles, when firft they begin to exert their powers, grow much redder, on account of the blood penetrating at that time into their fubftance, and in fome degree expanding it; and they become likewife much larger, by means of the blood-veffels which run through them, and extend their moving fibres.

From thefe particulars it evidently follows, that every contraction of a mufcle muft be preceded by fome degree of dilatation; and this dilation I fuppofe to be of three kinds. The firft is performed in the natural and voluntary contractions of the mufcles, by the blood forced into, and thereby partly dilating them. The fecond, which obtains, in natural contractions, I attribute to the contents, which by extending and dilating the moving fibres, and thereby drawing the blood more copioufly to them, occafions a relaxation of their contractile powers. The third kind of dilation is that which precedes the voluntary contractions, and feems to be produced by the determination of the antagonift mufcles; for thefe act upon the mufcles, oppofed to them, in the fame manner that the contents act upon mufcles, whofe motions are natural.

Now what does that fubtile matter, which conftantly flows through the nerves into the mufcles, contribute to their contraction? Is it derived to the moving fibres, ferving to open fome of the blood-veffels that furround the nerves lying within the mufcle? Or does it, by mixing with the blood, make it fuddenly effervefce and ferment, and fo excite that motion, by which the mufcles may again fhake off fuch fubtile matter, fo as to caufe an immediate contraction of the moving fibres? I muft own myfelf unable to give a fatisfactory anfwer to any of thefe queftions, and therefore leave them, as a moft fruitful matter of contemplation, to the difcuffion of others.

As to the other things which I have hitherto propofed, I think I may thence moft fairly conclude: Firft, That all the mufcles are naturally contracted; that is, they are in a ftate of contraction before they have performed any motion. Secondly, That their contraction is, in part, deftroyed by the blood, and fuch other humours as flow into them from their particular veffels; and that this is, as it were, the firft caufe of the dilatation or expanfion of the mufcles, though they ftill perfift in a ftate of contraction in a leffer degree. By this power alfo, the circumambient air is driven out of its place, and becomes condenfed, in the fame proportion wherein the mufcles are expanded. Thirdly, The contents of the vifcera, cavities, and little tubes of the body, about which the moving fibres are difpofed, contribute greatly, as a fecundary caufe, which obtains in natural motions, to the complete diftention or dilatation of the mufcles; whereas, in voluntary motions, fuch complete diftention and dilatation muft be attributed chiefly to the contrary determination of the antagonift mufcles: for the moving fibres in thefe two fpecies of mufcles, which are differently fituated, are confiderably expanded by thefe two caufes, which likewife difpofe the blood-veffels, belonging to the mufcles, to receive a far greater quantity of blood; fo that the dilatation being once arrived at its higheft pitch, the returning contraction may be the more powerful. Fourthly, The air, already repelled and condenfed, contributes greatly to produce this effect; for, by being immediately urged to dilate itfelf by the equilibrium of the atmofphere, it, in its turn, acts with the greater violence upon the mufcles, to oblige them to return into their late ftate of contraction; which is befides fo natural to them, that they would reaffume it of themfelves, fooner or later, without any fuch compulfion. Fifthly, We muft add to the caufes already affigned, the perpetual and natural irritations which the nerves are conftantly exciting in the moving fibres of the mufcles themfelves, and which are continually engaged in urging them to contraction. I would here be underftood to mean thofe ftimuli, which are produced by the blood in its circulation, and in its paffage through the arteries to the origin of the fpinal marrow, and all the nerves; or elfe thofe ftimuli which are communicated to the beginning of the fpinal marrow, and the nerves, by external objects, which make an impreffion upon the blood. Hence therefore, in the fixth place, the mufcles, as well the natural and moveable ones as thofe fubject to the dictates of the will, are neceffarily difpofed, and in a manner conftrained, to return to their original and natural ftate of contraction. Hence, feventhly, I may reafonably conclude, that in all the reciprocal contractions of the mufcles, their contents are again forcibly difcharged, fince the moving fibres, which were before extended, at this time come nearer again to each other, and become very compact, fo as to recover the fituation they were in, previous to their being dilated. For this reafon alfo, they muft then take up lefs room, though we may fee fome tumours arife at this time on the furface of the mufcles; thefe tumours being produced by the extraordinary compactnefs of the

the fibres, of which the muſcles are compoſed, and conſequently by the ſubſiding of the adjacent parts, rather than by any inflation of thoſe parts of which they themſelves conſiſt; as the authors, who have hitherto treated this ſubject, have falſly imagined. Seventhly, and laſtly, therefore, I from hence conclude, that all the actions of the muſcles conſiſt in contraction, or in a return to that form and diſpoſition they had before they were dilated; ſo that the muſcles, as often as they are again dilated, or determined a contrary way, by the cauſe already aſſigned, or by means of their contents, or by the action of the antagoniſt muſcles, conſtantly return afterwards to their former ſtate of contraction, whether the motions they are to give be natural or voluntary.

Though this be uſually the caſe, and principally with regard to the natural motions of the muſcles, it nevertheleſs is obſerved to take place in their voluntary motions alſo; though, to effect theſe laſt, the conſent of the will is likewiſe neceſſary. For we find, that, in all the voluntary motions of the muſcles, there is likewiſe abſolutely required ſome internal or external cauſe, by means of which a contraction of the antagoniſt muſcles may be determined another way.

Therefore, ſince all the muſcles are in a perpetual ſtate of contraction, it is eaſy to conceive, that the leaſt degree of determination, whatever cauſe may ſerve to produce it, is ſufficient to diſpoſe them to move the body, make it advance, remove it from place to place, and actuate it in a thouſand other different ways.

Nor is it in natural motions alone, that things are obſerved to proceed in this manner, as plainly appears by the contraction of the pupil of the eye, which inſtantaneouſly expands and dilates itſelf, by means of its muſcles, as the eye is more or leſs irritated by the particles of light. The ſame may be obſerved of the moving fibres of the inteſtines, which conſtantly alſo contract and expand themſelves, in proportion to their contents; ſo that their motion perfectly reſembles that of the ſea, whoſe waves follow and mutually preſs upon one another.

We often obſerve, that a natural contraction takes place in thoſe muſcles, which are ſaid to move as the will directs; as is manifeſt in our walking, ſtanding, and making uſe of our hands: for we certainly move our limbs almoſt every moment, without reflecting in the leaſt upon what we do. Thus, with regard to external objects, we often ſalute a perſon we meet, merely becauſe another in our company takes off his hat, or becauſe we are affected by ſuch external object, though we do not know who the perſon is we have ſaluted, nor ſo much as think of our ſaluting him. For this reaſon therefore it is plain, that as our memory is local, and is aſſiſted by the image of one thing in paſſing to that of another, and ſo on without end, the contractions of our muſcles are in like manner natural; and the muſcles themſelves are urged by one cauſe of motion to another, and from this to a third, and ſo on without any interruption.

It is for a ſimilar reaſon, that, when we find ourſelves too near the fire, we retire to a greater diſtance from it, and put our limbs, by means of various motions, into their former poſture, without attending in the leaſt to what we do; but merely in conſequence of the impreſſion made upon us by the irritating object. From hence it appears, that we can never be truely ſaid to move voluntarily, unleſs when the will itſelf is put in motion by the object, and then by its own motion produces a third; for whenever the light happens to be too ſtrong, we ſhut our eyes, turn our head aſide, and give ourſelves many other motions, as we are variouſly excited to them by the objects that preſent themſelves.

All theſe facts abundantly prove, that thoſe very muſcles, by whoſe aſſiſtance we perform our voluntary motions, are notwithſtanding always themſelves moved in a natural manner, not only becauſe an internal or external principle, cauſe, or object is alone requiſite to determine them; but likewiſe becauſe a voluntary motion is never produced, unleſs ſuch a determining principle, whatever that may be, precedes it, though it ſhould be but a thought merely caſual, let alone one previouſly excited. Cannot a ſimple dream, or ſome abſolute phantom, preſenting itſelf before us in the night, ſo affect us? Even in this caſe, we immediately ſtart, tremble, and perhaps get out of bed, ſhriek, and call for aſſiſtance. And all this we do merely becauſe we then juſt determine another way our muſcles, already prepared for action. We may obſerve the ſame things alſo in our ſpontaneous or natural motions, though ſuch motions can be but very ſeldom determined by us, and that alſo under certain conditions only. For our will, as I took notice in the beginning, has very little power in determining ſuch of the muſcles as have no antagoniſts; and indeed, if nature had not beſtowed upon us ſuch antagoniſt muſcles, we ſhould have been little better than vegetables, which cannot ſtir from the place wherein they have taken root.

It is evident, from the foregoing obſervations, that a great number of things concur in the contraction of the muſcles; and that we ſhould be thoroughly acquainted with that wonderful machine our body, and the elements with which we are ſurrounded, to deſcribe exactly one ſingle muſcle, and explain its action, in a ſatisfactory manner. On this occaſion, it would be neceſſary for us to conſider the atmoſphere, the nature of our food, the blood, the brain, marrow, and nerves, that moſt ſubtile matter which inſtantaneouſly flows to the moving fibres, and many other things, before we could expect to attain a ſight of the perfect and certain truth. For my part, I own that I have endeavoured to offer ſomething on this important ſubject worth the publick's acceptance; but yet I am ſenſible, that all this time I have been, as it were, repreſenting with a coal the

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sun's meridian rays: so that this my little essay can pretend to no merit, on any other account, but that of its conformity to Nature, which I hope I shall, in time, be allowed not to have misrepresented. And that time will be, when happier geniuses shall have made all these things clear and evident; for this may certainly be attained by laying aside all little thoughts of our own glory, in investigating the works of Nature, and thinking of His only, without whose assistance we could not even know any thing of them. At that happy period, the desire of writing for the sake of being talked of, will no longer prevail: we shall not then be anticipating our own praises, since all our intentions being directed to the honour of the Creator, we shall of course resist the corrupt motions of our hearts, apt to be delighted with flattery, and fond of obtaining the title of learned and ingenious men: all which I only consider as vanity of vanities, since truth is the only thing upon which we ought to depend, as on a firm foundation, and for which we ought to value ourselves. Who is it amongst us, that shall discover the truth, considering our blindness in judging even of the visible objects that surround us? Hence therefore, to conclude this essay, I shall observe, that every true and valuable discovery is the gift of the Divine Grace, which God distributes as he pleases, and makes manifest at his own time. My observations, concerning the nerves, may be found in my history of the Rhinoceros Beetle.

The End of the Natural History of Frogs.

A comparison of the changes in the Clove-Julyflower, with those in insects during their Nymph-state.

TAB. XLVI.

I Exhibit in the figure of this Table,

N°. I. The garden Caryophyllus, or Clove-Julyflower, under its first coat or tunick, within which it goes by the name of the seed of the plant.

II. The said coat or tunick fallen off from the latent rudiments.

III. The little new germen, or first shoot of the plant.

IV. The said germen opened into a few leaves.

V. The same germen or bud, when its folliculus or flower-cup is called a gemma, or bud; in which condition I consider it as a Nymph.

VI. The Caryophyllus or Clove-Julyflower itself, after it has burst open its gemma or bud, and is become ready to shew its seeds.

Having shewn in general, in the first part of this work, the similitude there is between the changes of vegetables and those of insects, I shall now, to make it the plainer, give a particular instance of it in the Caryophyllus or Clove; adding figures, to make every thing the more intelligible *.

Tab. XLVI. Fig. I. First then I give a figure of this plant's seed, as it appears to the naked eye; and then, at the letter A, I represent it as it appears through the microscope. Near the middle of it there appears a white protuberance; by which, while it remains in its cell, it receives life, nourishment, and increase, in the same manner with the eggs of insects in the ovary; so that we may consider this first principle, which is likewise found in other seeds, as the cicatrix of the navel-string, after it has been cut and tied up. There appear also, on the surface of the seed of the Clove-Julyflower, some very pretty little jagged unevennesses, interspersed with black spots; by means of which it looks not unlike that rugged skin called chagreen, and may indeed be very aptly compared to that kind of skin.

Fig. II. Secondly, I exhibit the coat, skin, shell, peel, rind, or tunick, which the Clove-seed throws off, in order to appear under the shape of a germen, or first shoot, III, just as insects cast their skins at the time of their changes.

After having represented the external appearance of the Clove-Julyflower-seed, N°. I. and A, I give the form of the skin it has cast off under N°. II. At the letter B, I give the true appearance of the seed contained within that skin or coat, drawn after nature; and at the letter C, as it appeared through the microscope, that my readers may be able to form juster notions of it. There are two things in this seed which deserve particular regard; namely, its prominent apiculus, or point, and that bivalve division or parting which is to be seen in the rest of its body. On the seed's being committed to the earth, we observe that the point or cone bends downwards, and divides into roots at its extremity, N°. III. whilst the rest of the body of the seed, opening more and more, at last throws off its external coat, N°. II. and constitutes the two first leaves of the future plant.

* In the course of vegetable nature, if the system of vegetable generation, just published by Dr. Hill, be found to answer equally in all other plants as in the instance there proposed, the origin of this part of Nature's products is very simple. There remains nothing of that incomprehensible doctrine of invigorating atoms, or a seminal air; but the whole operation is a continued growth. The fibres of the root are composed of five substances, laid over one another, and these terminate in the several parts belonging to the flower. The fleshy substance of the stalk terminates in the antheræ, and each termination of it is in a minute plant, which is lodged in a grain of farina, and defended by a watry substance: it is with this carried down the style into the seed-vessels, and lodged in the seeds. These cover it with new membranes; and when put into the ground, it casts off these membranes, and acquires its growth, just as this author observes of the Clove; confirming all his observations.

Fig. III. As reprefented after nature, under the third number. I here exactly exhibit the two firft leaves of this plant, with its root, and the fibres belonging to that part, and all the tender little rudiments of the infant Clove-Julyflower, which at this period exactly refembles an infect; that has juft crept out of its firft coat or fkin.

Fig. IV. Fourthly, I exhibit the germen of the Caryophyllus, or Clove-Julyflower, fomewhat more grown, and adorned all round with excrefcent leaves, which may very well be compared with the little bundles of hair fpringing from the fkins of Caterpillars.

Fig. V. I fhew in what manner the germen, or firft fhoot, has at laft grown to a gemma or bud, calyx or cup, which contains the latent Clove-flower, neatly folded up; in the fame manner that the Nymyh or Chryfalis contains the future flying infect. But there is this difference, that the parts of the Clove are uniformly furrounded with one continued coat or fkin, like the embryo Chicken in the fhell of its egg; whereas all the limbs of Nymphs or Chryfallides are wrapped up each in its own pecular covering, without being ever found under one common coat, unlefs it be in fuch infects as never throw off their laft fkin; as is the cafe in the fourth order.

Fig. VI. Laftly, I give a drawing of the Clove, at the time when it is in flower: when, after having burft its calyx, gemma, or bud, in the fame manner that the new Butterfly breaks from its Nymph or Chryfalis, and acquired its full fize, and age proper for fhedding its feed; it feems to wait, in its gay attire, for the coming of its mate, juft as infects do for an intercourfe with theirs. But as the Great Architect has not allowed plants a power of motion, and has ordered that they fhould propagate the fpecies without copulation, this little flower by degrees breathes forth its life, by a continual evaporation of the moft fragrant odours, refembling the breathing forth of fo many amorous wifhes; and finds only in its death the means of making itfelf immortal in its offfpring.

There are likewife infects, as I have elfewhere obferved, which, though diftinguifhed into males and females, propagate their fpecies without any venereal intercourfe. Of this kind is the Ephemerus. Even animals that have blood, as fifhes, for example, are found alfo to perpetuate themfelves in the fame manner.

If, therefore, we attentively confider the order in which the parts of infects, larger animals, and vegetables increafe, and alter from one form to another, and the other particulars belonging to fuch increafe and changes, we fhall evidently fee, that all God's works are really founded upon the fame rules, and agree together with an inconceivable regularity. But who is it, that, after ferioufly reflecting upon fuch an agreement, dare maintain, that the meaneft being under the heavens can owe to mere chance its effence, exiftence, perfervation, and rank in the creation?

As the generation, breeding, increafe, and changes obfervable in the Loufe, the Dragonfly, the Ant, Butterfly, and common Fly, how often foever repeated, are obferved to obey conftantly the fame laws, remain within the fame limits, and proceed in one uniform and certain manner; what reafon can there be to fuppofe, that the other parts of the creation fhould be governed with lefs wifdom, power, and goodnefs? What grounds for the leaft diffidence in the Great Lord and Mafter of fuch an univerfe? What powerful motives rather have we not, to acquiefce humbly in his counfels, adore his omnipotent hand, and praife his works, whofe exquifitenefs infinitely furpaffes the ftrongeft efforts of the moft fubtile and daring imaginations?

The Conclufion.

CONCLUDING this work, I cannot but obferve that the manner in which the infects I have treated of, and all others, efcape the injuries of the cold and rainy feafons, is of too much importance, and too furprifing in itfelf, not to deferve fome fhare of our attention. Experience has taught me, that they do this in four different ways.

Firft, I have obferved that the infects themfelves, which have acquired their full growth and perfection, outlive the rigours of winter; at which feafon they fo entirely lofe all power of motion, that when taken from the little places of retreat they had chofen for themfelves, during the autumnal months, as beft agreeing with their feveral natures and difpofitions, they cannot by any means reinftate themfelves. But if you cherifh them gently with a warm hand, or hold them at a proper diftance to the fire, they not only foon recover the power of moving themfelves, but likewife the ufe of their wings, with which they fly about as before, till the coldnefs of the circumambient air has again numbed them, or they have found other convenient winter-quarters. That all infects do not equally lofe this power of moving themfelves, is plain, among many others, in the cafe of Bees; for thefe not only open and fhut the doors of their hives in the winter feafon, but tenderly and diligently nurfe and rear their young offspring in the very depth of it. Hence it is, that not only young Bees may be found in the hives at the firft dawn of fpring; but that even it is a common faying amongft thofe that delight in this ufeful infect, that young Bees and Swallows make their appearance at the fame time.

Swallows feed upon Bees and other infects, which they feize in their moft rapid flights. For this reafon, in rainy weather, when no inſects are to be found in the air, theſe birds, in order to take them, fly near the ground; a circumſtance which has given a handle for that very abſurd notion of ſome people, that Swallows can foreſee an impending ſtorm; whereas, as I have been juſt ſaying, they ſkim the earth in heavy, cloudy, rainy, or ſtormy weather, merely to come at the inſects, upon which they prey, and which, at theſe times, always betake themſelves to reſt. For the ſame reaſon I believe Swallows conſtantly follow the courſe of the Sun; and when winter comes upon us, retire to the other climates which enjoy at that time a pleaſant ſpring, a fruitful ſummer, or a temperate autumn, and are therefore qualified to ſupply them with a ſufficiency of food.

I have obſerved, that ſome inſects can only endure the winter in the worm-ſtate. Theſe are found not only above and under ground, in the hollows of trees, between the leaves of plants, in the hearts of fruits, and in vegetable excreſcences, but even in the water, and are often encloſed in ice. But then it is obſervable of theſe inſects, that moſt of them are much ſtronger at this period, than ever they are afterwards, when they have gone through their changes, and are become capable of propagating of their ſpecies. Thus we find that the Water-worm, which changes to an Ephemerus, is ſo tenacious of life, that it can live many days after being run through with a pin; whereas in the Fly-ſtate it lives even without receiving the leaſt injury, but four hours at longeſt. However, we likewiſe know by experience, that theſe creatures, tho' vigorous and robuſt, periſh very ſuddenly, if they do not happen to find quarters adapted to their nature. Of this the Worms found in Hazel-nuts and filberts, are a ſtriking inſtance; for unleſs you place them in moiſt ſand, where they dig themſelves holes to ſerve them for winter-quarters, not only they die very ſoon, but even in the ſpace of one ſingle night, will harden, and dry to ſuch a degree, that they will in a manner fall to duſt between the fingers. I have obſerved alſo, that this is the caſe with the Worms bred in the tubercles of Mallow-leaves, tho' they never make holes for themſelves in the earth, in which they may paſs the winter, but defend themſelves againſt its rigours, by ſpinning a commodious covering for their bodies.

Thirdly, I find that other inſects paſs the winter in the Nymph-ſtate, in which they may be found as well on the ſurface of the earth, as buried under ground; and even in the water, where they will live for ſome months without any food; for at this time, they want ſtrength to take any, as well thro' the weakneſs of their limbs, as on account of the great quantity of ſuperfluous moiſture with which their bodies are charged. I have likewiſe remarked, as I already mentioned, that the greateſt part of theſe inſects, which outlive the winter in a perfect ſtate, require no food from one end of that ſeaſon to the other; for at that time their juices move very ſlowly, and are in a manner condenſed by the coldneſs of the circum ambient air; both which are ſufficient to account for ſo long a faſt.

Hence it is alſo, that theſe little creatures, when cheriſhed with the leaſt warmth, recover their former ſenſes and motion; whereas, before, they were ſo entirely motionleſs, as even not to void any excrements. And this circumſtance affords us another proof of their not taking any food at that time; for where there is no loſs, there can be no neceſſity for any nouriſhment to repair the waſte.

Fourthly, and laſtly, I have found inſects to ſurvive the winter in their eggs; in which, as I have heretofore obſerved, they often wear the form of Nymphs.

But I ſhall hereafter explain the advantages that accrue from this condition of Inſects in the Nymph, and other ſtates, when I come to deſcribe after what manner they bury their eggs in ſpring, on the approach of warm weather, in the tender germina or buds of plants, and in the leaves of trees; a thing which I mightily long for the ſatisfaction of ſeeing with my own eyes. Perhaps I may at laſt find the means of ſatisfying my curioſity. And, as no deſcriptions or drawings can impart full and juſt notions of the form and external appearance of theſe little creatures, I have formed a reſolution of collecting ſome hundreds of them, in order to preſerve them in balſam, after having ſufficiently dried them.

I could prove by the teſtimonies of people of all ranks, that I have in my muſæum ſpecimens of all the inſects I have ſpoken of in the foregoing treatiſe, to the number of more than twelve hundred, with their Nymphs, Chryſalides, and Vermiform-nymphs. But here, in order to do myſelf juſtice, I appeal to that moſt curious and learned gentleman the Abbé Boucaud, who, after he had been firſt to ſee me, in company with the celebrated Olaus Borrichius, Profeſſor of Phyſick in the Univerſity of Copenhagen, thought it not beneath him to return often to my houſe to examine the great number of natural curioſities I have there treaſured up.

I might likewiſe appeal to the moſt noble and accurate Paul Falconier, who ſome time ago did me the honour of a viſit, and was pleaſed to approve my occupations and ſtudies. But I would not have the readers imagine, that I have minutely examined every ſingle inſect of my collection; I have only reduced a great many of them to my four orders, as may appear to any one, that will be at the pains of conſidering what I have ſaid of theſe orders. And this caution I gave in the ſame place, for fear of deceiving others, and perhaps myſelf, with expectation of more being done in this branch of natural hiſtory than there really is. Though, let us do as much as we can, I believe it ſo far from poſſible to know every ſpecies of inſects, and the changes of each, that I believe the labour of ages would not be ſufficient to diſcover all the kinds of them. In the mean time, I challenge any one to produce a

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ſingle inſect, that may not be referred to one of the four orders of mutations which I have propoſed; for to me, if I may here truſt my reaſon, the thing appears impoſſible. I leave it to time to diſcover the truth of this aſſertion; and do not deſire any credit to be given to my relations, unleſs the things I ſpeak are found to agree exactly with the originals, as I have deſcribed them after nature with all the exactneſs and perſpicuity I was maſter of.

Having thus produced every thing, which in my opinion could be ſaid in general, or in particular, concerning inſects, I had reſolved to add another diſſertation on their eggs, worms, and Nymphs: but I muſt defer this to ſome other opportunity. I had even flattered myſelf with the hopes of being able to preſent the public with a ſeparate account of the little inſects found in the bodies of others of a larger ſize; but as yet I want ſufficient experiments for that purpoſe, though I am firmly perſuaded that nothing is to be attributed to chance in the generation of them.

I ſhall now ſay no more on this ſubject, as it is moſt evident that all God's works are governed by the ſame rules; and as the true and primitive origins of them are infinitely beyond the reach of our comprehenſion, ſo that we cannot be ſaid to know more than the bare outlines of that infinite Being's image, to whom they owe their exiſtence; ſo I may hence, for certain, conclude, that all the knowledge and wiſdom of philoſophers, conſiſts merely in an accurate perception of theſe elegant appearances or effects, which are produced by firſt cauſes, and are often themſelves, in their turn, the cauſes of other effects. For this reaſon, we ſhould ſtrenuouſly endeavour to make ourſelves well acquainted with theſe appearances, and then draw from them firm rules and principles; otherwiſe, as I have hinted in my preface, we may eaſily loſe our way, and ſtray into the paths of error, as diſputing on nature, which is quite inexhauſtible, without ſufficient experiments, which, on ſuch an occaſion, are as neceſſary to find us a path, conſidering with what darkneſs of ignorance we are ſurrounded, as a ſtaff is to the blind. It often happens, through our own fault, that thoſe things, of which we might acquire competent notions with very little trouble, become not only dark, but quite incomprehenſible to us, ſo as to encreaſe our blindneſs, by the erroneous inferences we draw from them, rather than add to our knowledge. Of this our great weakneſs, Goedaert alone is a ſufficient example; for that author, by falſely imagining to himſelf, for want of proper experiments, that Caterpillars, degenerated into crippled and imperfect inſects, as often as they performed their mutations, without being properly grown and fed for that purpoſe, not only in conſequence of this falſe poſition, involved all his other experiments in the moſt perfect darkneſs, but contracted himſelf ſuch a blindneſs, that he could not perceive one of the moſt excellent principles of natural hiſtory, though it lay directly under his eyes. I omit naming many other naturaliſts, who, too lazy, or too proud, to make experiments, and guided only by their weak reaſon, or weaker imagination, have argued on the mutations of inſects, with juſt as much propriety, as a blind man may be ſuppoſed to ſpeak of colours; inſomuch that I ſhould be aſhamed to put my readers in mind of their empty and childiſh reaſonings. Nor is there the leaſt ſhadow of excuſe, for the unwarrantable boldneſs of ſuch perſons, who were not aſhamed to ſpeak without any heſitation or doubt of things, whoſe cauſes and principles they were utterly unacquainted with. But, to ſpeak my mind with freedom and candour: if we are to regard as idle and vain, all thoſe reaſonings of ours, which cannot be primarily demonſtrated by experiments, and do not ultimately terminate in them, no reaſonings can be ſo ſtrong and certain, as thoſe which are drawn from the very obſervations and experiments, in which they may likewiſe be found to terminate. All ſuch arguments, therefore, as want this firm and immoveable baſis of experiments, are to be greatly ſuſpected of error, whatever ſyllogiſms and enumerations people may think proper to build them upon; and when they do not exactly agree with experiments, they deſerve to be rejected. Of this opinion was likewiſe the illuſtrious Des Cartes, who, in his eſſay upon method, has the following words. "For I was always of opinion, "that more truth is to be found in thoſe reaſon- "ings, which men make uſe of in the com- "mon affairs of life, whoſe bad ſucceſs may "prove a kind of puniſhment for their reaſon- "ing ill, than in thoſe which ſome idle doctor, "cooped up in his ſtudy, has invented concern- "ing this *entia rationis*, and ſuch other empty "queſtions, that conduce nothing to the eaſe and "happineſs of life, and from which he expects "no other advantage, unleſs that of reaping ſo "much the greater harveſt of empty glory from "his arguments; as they contain leſs of truth "and common ſenſe, on account of the extra- "ordinary ſtrength of genius, and application "requiſite to give an impoſing air to ſuch ab- "ſurdities."

If we duly conſider the words of this able philoſopher, and the great weight and importance of experiments, I believe we ſhall find it not unjuſt to dignify with the name of reaſon that faculty of our minds, by the aſſiſtance of which, we form clear and diſtinct notions of things, whilſt we make proper uſe of our ſenſes in ſufficient experiments, ſo as to be able afterwards to effect exact copies of the originals we have thus endeavoured to be thoroughly acquainted with. For this reaſon it is, that our idea of any thing is ſaid to be more or leſs clear and diſtinct, according as we can produce another thing more or leſs like it; and are therefore ſaid to have more or leſs the power of it. This being granted, it ſhould follow, that we have no clear, diſtinct, or perfect knowledge of any things, except of ſuch as we can truly and effectually produce, according to the notions we have of them: ſo that ſolid and perfect knowledge muſt be allowed to be a very uncommon thing in man, and to be confined within very narrow bounds. This is an im-

imperfection we ſhould readily confeſs, if a principle of vain glory, cheriſhed by that very ignorance, did not prevent us. To give an inſtance of theſe things, which are in ſome ſort underſtood by us, I believe phyſicians, if they had clear and diſtinct ideas of the ſtructure of our bodies, and of the motions of the blood, and other juices belonging to them, would be able to mend radically any unnatural diſpoſition in theſe parts, as they could then prove the validity of ſuch clear and diſtinct ideas, by reducing them to the teſt of experiments, which is allowed in every country to deſerve credit, more than reaſon itſelf. But as hitherto they are very unhappy in their attempts to cure our diſorders, and are always perplexed by croſs events, from the weakneſs of their reaſonings; we cannot but allow from this, and all, that the great Deſcartes has beſtowed no commendations on experiments which they do not highly deſerve.

It is plain, from what has been ſaid, that ſomething may exiſt in the underſtanding, which never before had been taken notice of by the ſenſes, tho' we cannot comprehend them clearly and diſtinctly, unleſs they terminate in the ſenſes, or at leaſt may effectually terminate in them. Beſides, our underſtanding becomes at length ſo diſcerning, as through a frequent and attentive obſervation of experiments and ſenſible effects; ſometimes we are enabled to judge truly and ſolidly, without any previous experiment of things, which have never fallen under the cognizance of our ſenſes. To this purpoſe, is what Ariſtotle ſays in the tenth chapter of his third book concerning the generation of inſects. " We " muſt truſt our reaſon, if what it demonſtrates " be found to agree with the informations of " our ſenſes."

All things therefore duly conſidered, it does not ſeem unreaſonable to determine, that if we had clear and diſtinct ideas of the ſtructure of the human body, the motions of its juices, and every thing elſe relating to that wonderful fabrick; not only we ſhould be able, by making a proper uſe of ſuch ideas, to mend it when impaired, but might even ſo far go beyond the bounds of nature, as to reſtore its health and vigour, when entirely loſt and decayed. For our induſtry ſucceeds the better, in producing things the more clearly and diſtinctly it comprehends them; whilſt ignorance, on the other hand, is attended with a proportionable degree of weakneſs.

But as it is not always in our power to make accurate experiments or obſervations, ſo neither are ſuch experiments always ſufficient to give us clear and diſtinct notions of the things themſelves. Such, for example, as on account of their extreme minuteneſs or remoteneſs, elude the ſharpneſs of our ſight. Let therefore no one be childiſh enough to perſuade himſelf, that we can, by the bare efforts of our reaſon, ever thoroughly underſtand the genuine cauſes of ſuch things; not to ſay the true effects produced by them.

For the higheſt degree of wiſdom we are capable of attaining, does not conſiſt, as I obſerved before, in the knowledge of cauſes, but only in the clear and diſtinct comprehenſion of the true appearances or effects, by which ſuch cauſes diſcover themſelves to our ſenſes; but we afterwards make uſe of theſe effects, as ſo many ſteps by which we may climb to the firſt cauſes, and by the juſt notions we thus acquire, we are enabled to produce an infinite number of things requiſite to make life eaſy and happy. Nay, even this knowledge reaches no higher than the perception of theſe effects, as they are made known to us by a circumſpect uſe of our ſenſes. And therefore, all our reaſonings that are drawn from experiments already made in one caſe, and then applied to another, in which we have not as yet made any, are to be held as dubious and ſuſpectible till they end in, and are confirmed by immediate experiment.

For this reaſon I am greatly pleaſed with the illuſtrious Harvey, when in the preface to his treatiſe on the generation of animals, he ſpeaks of the methods of finding truth, in the following words: " The preſent method " therefore, of inveſtigating truth, is alto- " gether erroneous and childiſh, whilſt the " generality are taken up in inquiring not what " things are, but what others ſay of them, and " then drawing an univerſal concluſion from " ſingular premiſes, to which they often af- " terwards add analogical reaſonings, and al- " moſt always palm upon us for true, things " that are ſeldom more than at the utmoſt " probable. Hence it is, that many ſophiſts, " after ranſacking the inventions of others, " preſent them to us as their own, though " they have done no more than change the " original author's order and words, and made, " perhaps, ſome few inconſiderable additions; " by theſe means they render philoſophy, " which ought to be certain and perſpicuous, " dark, intricate, and confuſed. For thoſe, " who whilſt they read an author's words, do " not abſtract the images of things, compre- " hended in their words from their proper " ſenſes, inſtead of furniſhing their minds " with true ideas, fill them with falſe idols " and empty fancies, which they work up in " their imagination, into ſhadows and chime- " ras; ſo that all their fine theories or con- " templations which they dignify with the " name of knowledge or ſcience, ought ra- " ther to be conſidered as the dreams of men " awake, or the ravings of lunaticks." And a little before, he ſays, " For the images of " things that come under the cognizance of " our ſenſes, remain when the things them- " ſelves have diſappeared; and theſe images " conſtitute memory, which, by taking in a " great number of objects, forms in its turn, " what we call experience; and from expe- " rience we derive univerſal reaſon, definitions, " and maxims, or common axioms, which " are the certain principles of knowledge." He again ſpeaks to the ſame purpoſe in his forty-fourth exercitation, and in the following terms. " It is therefore, no ſuch wonder, " that ſo many errors ſhould have deſcended

" even

"even to our times from the remoteſt anti-
"quity, with the unanimous conſent and approbation of mankind; or that men of great abilities in ſome reſpects, ſhould have committed miſtakes, as they thought it ſufficient to be wiſe with the wiſdom of others, or learned with their learning, and to fill their memory with the opinions of learned men. But thoſe who philoſophize in this manner by traduction, if I may thus expreſs myſelf, are not a whit wiſer than the inanimate books through which they come at their ill-digeſted notions."

Thus alſo, the great Deſcartes ſpent his whole life in endeavouring to make philoſophy a practical ſcience, inſtead of a merely theoretical one, as it had been to his days, that thereby he might make it ſubſervient to the moſt important purpoſes of life and health. But as he conſidered he might not perhaps live long enough, or be able to make enough of experiments to accompliſh ſo noble a deſign, he warmly exhorts men of ſuperior abilities to ſuch a taſk, and to loſe no opportunity of making experiments, and reducing every thing to that ſure and infallible teſt. To this purpoſe he ſpeaks as follows, in his eſſay on method. "But as I had propoſed to ſpend my whole life in the acquiſition of ſo neceſſary a ſcience, and fell upon a method, which I thought would enſure me ſucceſs in the enterpriſe, unleſs death, or a want of expements ſhould interpoſe; I judged the beſt thing I could do to remove theſe obſtacles, would be to lay before the publick a faithful account of all the advances I had made, however inconſiderable; and at the ſame time endeavour to perſuade men of extraordinary genius to purſue what I had begun, and make each of them in particular as many experiments as he could, and then inform the publick of every diſcovery made this way, that by the laſt beginning where their predeceſſors in this uſeful undertaking had left off, and then joining together the lives and labours of a great many, we might ſooner obtain our purpoſe, than could be done by the unaſſiſted endeavours of ſingle perſons. I have always found the more any perſon knew, the more he ſtood in need of making further experiments."

The illuſtrious Boyle, to whom mankind is ſo highly obliged for his admirable writings, not only conſtantly endeavoured, and that with great labour and expence, to add to the number of uſeful experiments already made, and thence derive certain, and ſolid concluſions, but likewiſe ſtrenuouſly, tho' candidly, endeavoured to prove by the weightieſt arguments, the great uſefulneſs and neceſſity of experimental phyſiological. Theſe are his words, in his proemial eſſay to certain phyſiological eſſays.

"If men could be perſuaded to mind more the advancement of natural philoſophy, than that of their own reputations; it were not, methinks, very uneaſy to make them ſenſible, that one of the conſiderableſt ſervices that they could do mankind, were to ſet themſelves diligently and induſtriouſly to make experiments, and collect obſervations, without being over-forward to eſtabliſh principles and axioms, believing it uneaſy to erect ſuch theories as are capable to explicate all the phænomena of Nature, before they have been able to take notice of the tenth part of thoſe phænomena that are to be explicated. Not that I at all diſallow the uſe of reaſoning upon experiments, or the endeavouring to diſcern as early as we can, the confederations, and differences, and tendencies of things: for ſuch an abſolute ſuſpenſion of the exerciſe of reaſoning were exceeding troubleſome, if not impoſſible."

But that I may at length conclude, the ſucceſs of my labours ſo apparent in every page of this work, proves abundantly all that I have advanced on this occaſion. For when I conſider within myſelf, that by the help of experiments, I have here been able to diſcover things, which not only men of moderate parts, but even the greateſt geniuſes, from the age of Ariſtotle, to the preſent, during an interval of about two thouſand years, have in vain endeavoured to find out, I cannot but look upon this happy reſult of my labours as the beſt proof of the ſuperior excellency of experimental philoſophy. Nor is there here any occaſion for a great parade of words to demonſtrate the abſolute neceſſity of diligently examining things in themſelves; for if our juſteſt reaſonings ought to terminate in experiments, to be built upon experiments, and purſue the courſe preſcribed us by experiments, who is there, that would not, in forming his judgment of things, much rather truſt to experience, then to the idle fancies of his imagination; nay, I may aſk, who will hereafter dare to affirm, that we may depend upon our reaſon alone, to come at the knowledge of every kind of truth? whereas it is moſt certain, that by making a proper uſe of our ſenſes, we may from the things we ſee, gather ſufficient information concerning thoſe that we cannot: the end of the general and particular treating of inſects, all which I have reduced to four orders, and proved to reſt upon one ſingle foundation, which is the Nymph.

A General Analogy, or Comparifon of the

MUTATIONS and ACCRETIONS

As to PARTS and LIMBS,

As well in Eggs, Worms, and Nymphs, as in Infects among themfelves: Alfo in thofe Mutations, and Accretions which we obferve in an Animal of the red-blood Species, and a Vegetable clearly exhibited at one View.

Tab. I.	Tab. XII.	Tab. XVI.	Tab. XXXIII.	Tab. XXXVIII.	Tab. XLVI.	Tab. XLVI.
					The Frog.	Caryophyllus, or Clove July-flower.
First Order.	Second Order.	Third Order. First Species.	Third Order. Second Species.	Fourth Order.		
I. The Loufe in its firft fkin, within which it is called a Nit.	I. The Worm of the Libella, or Dragon-fly, in its firft fkin, within which it is called an Egg.	I. The Worm of the Ant in its firft fkin, within which it is called an Egg.	I. The Caterpillar of the Phalæna or Moth in its firft fkin, within which it is called an Egg.	I. The Worm of the Fly in its firft fkin, within which it is called an Egg.	I. The Worm of a Frog in its firft fkin, within which it is called an Egg.	I. The Germe of the Caryophyllus in its firft coat, within which it is called a feed.
II. The faid fkin, or coat thrown off.	II. The faid fkin, or coat thrown off.	II. The faid fkin, or coat thrown off.	II. The faid fkin, or coat thrown off.	II. The faid fkin, or coat thrown off.	II. The faid fkin, or coat thrown off.	II. The faid coat thrown off.
III. The Loufe divefted of its faid fkin.	III. The Worm of the Libella divefted of its faid fkin.	III. The Worm of the Ant divefted of its faid fkin.	III. The Caterpillar of the Phalæna divefted of its faid fkin.	III. The Worm of the Fly divefted of its faid fkin.	III. The Worm of the Frog divefted of its faid fkin.	III. The Germe of the Caryophyllus divefted of its faid coat.
IV. The Loufe more grown.	IV. The Worm of the Libella more grown.	IV. The Worm of the Ant more grown.	IV. The Caterpillar of the Phalæna more grown.	IV. The Worm of the Fly more grown.	IV. The Worm of the Frog more grown.	IV. The Germe of the Caryophyllus more grown.
V. The Loufe confidered as an Animal-Nymph.	V. The Worm of the Libella changed into a Worm-Nymph.	V. The Worm of the Ant changed into a Nymph.	V. The Caterpillar of the Phalæna changed into a Chryfalis.	V. The Worm of the Fly changed into a Vermiform-Nymph.	V. The Worm of the Frog changed into a Tadpole.	V. The Germe of the Caryophyllus changed into a Follicle or Nymph.
VI. The Loufe full-grown, and in a condition to propagate its fpecies.	VI. The Libella full-grown, and in a condition to propagate its fpecies.	VI. The Ant full-grown, and in a condition to propagate its fpecies.	VI. The Phalæna full grown, and in a condition to propagate its fpecies.	VI. The Fly full-grown, and in a condition to propagate its fpecies.	VI. The Frog full-grown, and in a condition to propagate its fpecies.	VI. The Caryophyllus full-grown, and in a condition to form its feed.

APPEN-

APPENDIX.

The anatomy of the * *Sea-Sepia or Cuttle-Fiſh. Inſcribed to the moſt excellent Francis Redi, phyſician to the great Duke of Tuſcany, a moſt indefatigable ſearcher into the miraculous works of Nature.*

THE INTRODUCTION.

THERE is not among the ſoft fiſhes, which are ſaid to have no blood, any that claims our attention ſo much as the Sepia or Cuttle-fiſh; as well on account of its external figure, which is wonderful beyond all deſcription, as for the ſtructure, order, and diſpoſition of its internal parts, which moſt evidently ſhew themſelves the work of infinite wiſdom. I ſhall not ſpeak of the common miſtakes and errors of the generality of mankind concerning this creature, much leſs attempt to cenſure thoſe eminent writers, who before me have treated of this ſubject; for every one of them wrote of natural hiſtory according to his own genius and fancy. I chooſe rather to exhibit in a few words the external and internal parts of this extremely ſingular animal. And whilſt I do this, I appeal for the truth of my relation to the reader's own eyes, by deſiring him to inſpect the creature itſelf. Certainly, thoſe who would avoid being impoſed upon, ſhould ſtudy nature in herſelf; for ſo many fallacies and errors have crept into the writings of preceding ages, that people cannot but be led aſtray by them, as often taking things upon truſt, they neglect to ſee for themſelves. This will evidently appear by the following hiſtory, which, tho' a new relation, does no more than exhibit in a new dreſs the truth itſelf, than which nothing can be more ancient.

The Sepia or Cuttle, is a creature that has eight legs, two long arms or claws, a ſhort head, very large eyes, and the beak of a Parrot. The body is ſomewhat oblong, conſiderably broad and thick; and the back is prettily marked with ſeveral whitiſh furrows, and elegantly dotted. The Sepia or Cuttle is frequently found dead on the Dutch coaſts in the ſummer months; it was there I firſt met with ſome of them, and made drawings of their viſcera. But the hiſtory I am now about to give, is no more than a bare narration of what I obſerved in two of them, which were brought me from the ſea about the middle of May, and of which I took ſhort notes and drawings, in great haſte, during four days that I ſpent in this inquiry.

The moſt conſiderable parts of the Sepia, which firſt offer themſelves to our view, are its legs and arms or claws. The legs to the number of eight, are ſeated round its mouth. The two forefeet, Tab. L. Fig. 1. *aa*, are very thick, and appear broad, when the fiſh lies flat upon its belly. The other ſix are very like one another in ſize and form. One ſide of all theſe feet is covered with a common ſkin, which is pretty ſtrong, and of a purple colour interſperſed with many black ſpots; beſides which, the two larger legs are marbled as it were with ſome white furrows *b*.

But the moſt remarkable thing in theſe legs, is their being all thick ſet with a prodigious number of particles like flattiſh but hollow globules, and each fixed to a kind of ſtalk *ccc*; Yet the extremities of the arms or claws, to which authors have given the name of Promuſcides, are ſtill more largely furniſhed with theſe kind of tubercles. Theſe brachia or arms are very long, if compared with the legs, and they are placed near the bill or beak, in the midway between the broadeſt pair of legs, and the pair next to it *dd*. They are of a cylindrical figure, and of a white colour intermixed with black and purple ſpots. The ſubſtance of them, as well as that of the *xx* legs, is ſoft; and they have the ſame kind of ſkin, but it covers them all over, which is more than it does in the legs. The extremities of the legs and arms are pretty much of the ſame form, only that the tubercles of the arms are larger, and the ſtalks upon which theſe tubercles grow much longer and ſtronger than thoſe of the legs *e*. The extremity of one of the arms is always larger than that of the other.

As theſe globules are hollow, authors have thought proper to call them Acetabula or ſawcers. Rondoletius tells us, that this ſtrange fiſh can faſten itſelf by its arms to any body it meets with, in the ſame manner as cupping-glaſſes ſtick to the ſkin by a kind of ſuction. And certainly this is a very juſt compariſon, as appears from the moſt wonderful contrivance of theſe parts, which I ſhall preſently deſcribe.

It is to be remarked, that the ſame kind of ſkin which covers the under ſurface of this animal's eight feet, does not extend to the upper; it

* The Sepia or Cuttle-fiſh is one of the animals of the ſixth claſs in the Linnæan ſyſtem, which he entitles Vermes: it comes under the ſecond order, to which he has given the name Zoophyta, and is arranged with the Star-fiſh and Polype. The characters of the genus are theſe; the body is oblong and depreſſed, the feelers or tentacula are ten, and two of theſe are much longer than the others, and have a kind of foot-ſtalks. Beſide the Cuttle-fiſh, this genus comprehends the Loligo, which the French call the Calamarie, and the Octopedi deſcribed in the Upſal-tranſactions. Of the Calamary we ſhall have occaſion to ſpeak largely hereafter.

goes no further than the globules *fff*, and there it forms a loose border to the feet, which when the creature swims, floats in the water. For this reason, that loose skin can cover all the surface of the feet, and their acetabula at the creature's pleasure, as the edges and corners of a cloth, may fold over any thing that is laid upon it. Nor is it to the middle and basis of the legs only that it performs this office, but even to their sharp ends, where the acetabula *gg* are smaller than in any other part. But these borders are more conspicuous about the extremities of the arms than elsewhere; for which reason I have represented those belonging to one of the arms *hh*, as they appear when they cover the globules, except its being a little turned back.

The skin which spreads itself over the intervals of the globules, and covers the inside of their stalks, and even the external skin's borders which I just now mentioned, is in some measure as it were muscular, and is of a much more delicate texture than the other skin. It must likewise be observed that the parts supporting the acetabula tho' called stalks, are not really such, but pretty conspicuous muscles administring to the acetabula.

I have observed also, that these little muscles are here and there distributed over the inside of the borders of the external, so as to be able to move those parts as well as the acetabula. For this reason I consider what is called the skin in these places as a muscular substance.

I have represented some of the muscles belonging to the acetabula of their natural size, in order to give the reader a more just idea of them. Tab. L. Fig. 11. N°. 1. shews, how the muscle is inserted underneath into the base of the globule, where it is somewhat hollow; and how by expanding itself, and then contracting again a little, and afterwards expanding itself again, it in a manner entirely forms the globule. For as far as I could inform myself by dissection, the acetabula are altogether muscular, and the tendons of those muscles are inserted into a ring of a substance between horn and bone, which lies between the moving fibres of every acetabulum.

It appears, on examining the upper side of the acetabulum, and the structure of its hollow, N°. 2. that it is likewise muscular in these places; the little ring now mentioned shews itself very plainly on this occasion. The upper edge of this ring is generally black, but this blackness is only superficial, being no more than a portion of the external coat of the globule, and therefore it may be easily removed.

By taking out this ring, and placing it on its side, N°. 3. we obtain a good view of its construction, and the blackness of its upper edge; we even discover by placing it in this situation, in what manner it is perforated in the middle, and its upper and lower edges waved in a serpentine manner. This construction, so well contrived for receiving and holding the musclar fibres, wonderfully contributes to keep the ring firm in its situation.

The better to shew the black edge of this ring, and the manner in which it is turned, I have represented it, N°. 4. in a convenient situation to shew all its upper circumferences: and have added a small segment of it, N°. 5. to make the construction of this part as intelligible as I possibly could; for it would be extremely difficult to understand the use of this ring, without knowing exactly in what manner it is formed.

The advantage of this singular construction consists in this, that the muscular fibres of the acetabulum can by contracting themselves raise the stalk or muscle of the globule very high within the cavity of the ring, and thereby of course streighten the cavity of the acetabulum, whilst on the other hand the muscle of the stalk, by exerting itself at the same time, again raises itself and its fibrous parts out of the globule, so as to make its cavity much wider and more spacious than it was before.

Nor do I in the least doubt, but all the Cuttlefish's power of fastening itself to bodies, or taking hold of, and conveying any thing to its mouth, depends entirely on the singular construction, and exertion of the part just now described. Whenever this strange animal applies to any body that prodigious number of globules, with which its arms and legs are furnished, and then immediately withdraws the muscular stalks of these globules, from within the hollows of the acetabula, taking care at the same time, not to let any water into these cavities, the water repelled in this manner must press such parts against the body, against which they lie, with an extraordinary force: And this end is the more certainly obtained, as the borders of the skin which covers the arms and legs are likewise muscular; and by containing and enclosing the globules at the time of their action, contribute greatly to hinder any water from insinuating itself within the cavities of the acetabula.

We must therefore be more than blind, not to discover by this single instance, how wonderful God is in his works, seeing he has here effected, by means of repelled water, such a suction (to make use of a common expression) as he has produced by means of repelled air in the vital element we breathe. Hence also we may easily understand, what Rondoletius says of the brachia or arms of this animal; and of the manner wherein it remains in the most stormy weather immoveably fixed, and as it were at anchor at the bottom of the sea; for at such times no doubt it dilates its acetabulum to the utmost breadth, and fastens itself in its post, by their means with an extraordinary degree of power.

The beak, Tab. L. Fig. 1 *i*, which lies in the center of the legs, is like that of a Parrot, and consists as it were of two maxillæ or jaws, both moveable. These maxillæ join each other in the same manner with the body and the lid of a box, when the former slides up within the latter. The flesh which surrounds this beak, instead of lips *k*, is regularly orbiculated and sometimes appears plaited or folded back in wrinkles, like a purse that has a border to it.

Under the beak and legs appears the head, in which the eyes *ll* are very conspicuous. The most remarkable part of these is the cornea, which lies upon

upon them fo loofely, that it may in a manner be moved backwards and forwards like the membrana nictitans or winking membrane in birds. The operculum *m m* of the pupil, makes its appearance very elegantly thro' the cornea, which is tranfparent: but this operculum does not appear any where to fo much advantage as in the Ray-fifh, as Stento has moft exactly defcribed it. I have likewife difcovered this operculum of a black colour in the eyes of horfes; at one fide of the eye, the pupil projects a little, nor is it exactly round in this place. On drawing this operculum over the pupil, the eye lofes its fight. Some time ago, I obferved that the crocodile has a cat's eye, having an aperture to its pupil, which in the day-time refembles a long flit.

The Cuttle-fifh's neck is very fhort, and like the head is elegantly covered with black fpots upon a purple ground. The upper extremity of the back *n* rifes by a remarkable procefs over the neck; fo that the creature can hide its head under it, in the fame manner that the naked Snail hides its head under its verge or border.

All the parts of the Cuttle-fifh, yet mentioned, are foft, except the beak, and the cartilaginous rings of the acetabula. But the back is hard, firm, and incapable of motion, as the bone of the creature lies here, running quite thro' the back to the tail, without any vertebræ or like divifions. The mufcles of the creature are inferted into this bone. That part of the body which lies at the two fides of the bone, is foft and mufcular *o o o o*, which makes it probable, that this extremity, which terminates the back and belly of the Cuttle-fifh, may be of great ufe to it in fwimming. The back-bone alfo is well contrived to anfwer the fame purpofe, for it floats on the furface of water, even when it is juft taken out of the fea, and before it has had time to lofe by drying any of thofe pieces, which may be fuppofed to make a confiderable part of its weight.

The colouring of the back afforded a very entertaining fight, for its furface was raifed with a great many white ftreaks and furrows like fo many veins interfperfed with very fmall black fpots; but between thefe ftreaks the fkin was of a deeper colour, and marked with larger black fpots. Where the ftreaks ended, there appeared a great number of white fpots, which were either round or oval, even the extremities of the ftreaks were either round, or fhaped like a pear. The foft margin of the body was of a fomewhat deeper purple, fprinkled with fmaller black fpots, and fome others that were round and white; but it then grew whiter towards its extremity, where it ended in a deep purple edge. On the hinder part, where in other animals are feated the arms and tail, the margin was fomewhat divided or dented in, *p*; fo that from this nick, the body of the Cuttle-fifh appeared naturally divided into a right and left fide.

On handling the beak a little, it fell from the head, which gave me a very convenient opportunity of examining its fubftance, colour, and conftruction. The fubftance of this part is between bone and horn, and thicker and more compact on its upper part, with which the animal bites, but on the lower, to which the mufcles of the beak are fixed, more tendinous and membranaceous. In figure it refembles the Hawk's or Parrot's beak, and has many things in common with it. The upper part, which, as I faid before, in the thickeft, is of a deep brown colour, which grows redder and redder in proportion as the beak grows more and more membranaceous. But as the beak confifts of two maxillæ or jaws, an upper and a lower, which meet together, and move one upon and towards the other, fo likewife they differ in conftruction. The lower part fpreads as it were into two wings Fig. III. *aa*, between which the upper part finks, and fo meets this lower. The lower maxilla, or jaw, is on its hinder part folded back within itfelf *b b*, not unlike a paper tube bent back, by which means its fharp extremity becomes twice as thick and ftrong as it would otherwife be. On the lower part it bends itfelf back, fo as to form a hollow furrow *c*. This beak appears altogether fibrous, and feems to be compofed of membranaceous tendons, hardened by degrees into a horny bone. The upper jaw of the beak *d*, is of the fame fubftance with the lower, from which it only differs in its curvature and form; befides, its internal finus is much more deep and broad *e e*, to afford the tongue, which lies in this finus, the greater liberty to move itfelf. The mufcles alfo find better infertions in the hollow finufes of this horny bone, in whofe membranaceous expanfions they are fixed.

The tongue, which is thought to be a fungous fubftance, confifts of feven little cartilaginous bones, which lie very clofe to each other, and are befides united by means of a particular membrane. The upper extremity or point of the tongue is fomewhat crooked Fig. IV. *a*, but the lower part is united with fome mufcular and fungous flefh, in which it lies, as in a hollow tube. This flefhy portion of the tongue is full of wrinkles and elegant folds *b*, which feem to contain a great many fmall falival ducts. I have found by diffection that a very confiderable falival duct *c* opens and difcharges into this flefhy part.

This falival duct defcends by a long tube, *d*, through the animal's neck into its breaft, where it divides into two branches, that terminate in two very confiderable glands, *e e*. Thefe glands feem, on nice infpection, to be of the kind called conglobate, or by anatomifts, though externally, they appear of the other kind, known by the name of conglomerate. On opening them, I found a kind of hollow in them, made to receive the faliva, fecreted by their fungous fubftance; but I could not difcern the ramifications of thefe two parts, which, no doubt, fpread themfelves through the parenchyma or flefhy fubftance of their glandules; but the coloured liquors I injected, fhewed no fuch thing. Thefe glands lie within the breaft, on each fide of the gullet or throat, in fuch a manner, that this laft channel runs above and between them: this beft appears on opening the body of the fifh, af-

 ter

ter turning it upon his back. The tongue and parts belonging to it, when taken out of the beak, generally bring along with them fome of the mufcles, two of which, *f f*, I have here given a cut of. But I return to the tongue.

The contraction of the tongue, which, as I have faid, confifts of feven cartilaginous bones, becomes very vifible on parting it from the fungous flefh to which it is faftened, and in which it is wrapped up; but it may be made ftill more confpicuous, by drawing off the membrane, Fig. v. *a*, with which the inferior part of the tongue is covered, and afterwards feparating from each other with a fine knife, at the extremities, the little cartilaginous bones, of which it confifts, *b*. After treating the tongue in this manner, we may fee by the microfcope, that every one of thefe bones is furnifhed with above fixty crooked cartilaginous papillæ, Fig. vi. *a*, in form of teeth, and in fome meafure refembling the papillæ on the tongues of black cattle. By thefe the Cuttle-Fifh, when feeding, is the better enabled to move its food, and difpofe it for an eafy fwallowing. The fore-part of thefe papillæ, is of a clear and tranfparent amber colour, but the hinder-part, which conftitutes the bafe, or root of the tongue, is of a tranfparent white. The beft way to examine the tongue, is to invert it, and then furvey it with a microfcope on the under or lower fide, where its bafe or root lies; for, by this means, we difcover, that in ftructure it exactly refembles the moft regular web, Fig. vii. *a a*, from the frame, or combination of the cartilaginous bones already defcribed. The fight of this admirable contrivance, induced me to take out the tongue and dry it; but all its beauties vanifhed almoft entirely in the operation.

The body of the Cuttle-Fifh, when laid on its back, appears much whiter, and has by far fewer fpots. But the moft remarkable thing in this animal, is an opening in this under part of its body, in which an expanded hand may be entirely buried: this is between the body and the mufcular partition that covers it on its fore-part.

On opening this lower part of the body, Tab. LI. Fig. i. *a a*, in a right line through the middle of the belly, *b b*, from the beginning of the breaft to the tail, *c*, and this without injuring the contents; there immediately appear feveral remarkable internal parts, fome quite plain and naked, and others appear more faintly, as lying deeper in the breaft and belly, and only fhewing themfelves through fome interpofing tranfparent membranes.

The firft thing which prefents itfelf here, is a bag or bladder lying in the fuperior region of the breaft, which I call the common excretory bag, or bladder. The colour of this part is white, its fubftance is mufcular, and its fhape is like that of an inverted funnel, very fpacious and broad at the bottom, *d*, and flender at top, *e*, it joins on each fide with two oval cartilaginous, mufcular and hollow little bodies, *f f*, which ferve to receive thefe two greater papillæ, or cartilaginous eminencies, *g g*, which I have reprefented, one on each fide of the mufcular partition, loofely furrounding the contents of the belly, and cut away by me upon this occafion. By this junction of the excretory bladder, and thefe oval bodies, it is provided, that nothing fhould move foon, or be difcharged by the inferior parts of the body, without paffing through this excretory bag; and the fame wife difpofition of thefe parts, keeps the Fifh's eyes from being injured by the excrements, fperm, eggs, and black liquor, which all make their way through this funnel, as they certainly would, if thefe difcharges were to be made between the funnel, and the mufcular partition of the body: for this reafon alfo, nature has formed this bag or bladder of a mufcular fubftance, the better to difcharge its contents at the creature's pleafure.

As yet, I cannot fay for certain, whether or no the papillæ juft fpoken of, are naturally and conftantly united with the oval acetabula, which I have defcribed; for I have fometimes found them independent and disjoined. But as I could never find in thefe parts, the leaft mark of any rupture or fraction, the acetabula, on the contrary, always appearing quite fmooth, and the papillæ of a bright polifh; I think it very probable, that the Cuttle-Fifh has a power allowed it by nature of joining and feparating thefe parts, as neceffity requires.

The office of thus joining and feparating thefe parts, I am inclined to attribute to a pair of compact, oblong, white mufcles, Fig. i. *h h*, which at their upper extremities unite with the acetabula, and are contained within the lower edge of the excretory bag or bladder. Thefe mufcles are among the parts, which appear naked in the breaft, without any previous diffection. Nor do I fee any ufe they can be of except that which I have affigned them, of joining and feparating the acetabula, and the papillæ, by doing which, the excretory bag or bladder is at the fame time dilated, fo as to facilitate the difcharge of its contents through the funnel already mentioned.

Hence, it is impoffible to thruft all the hand in the manner beforementioned, into the Cuttle-Fifh's body, without firft feparating the papillæ from their acetabula.

On opening this excretory part, it appears compact and mufcular, and forms withinfide, on its lower part where it joins the breaft, a kind of lobe in the fhape of a broad tongue.

The other parts that appear in this place, without further diffection, are the gills, *i i*, of a foft fpungy fubftance, placed on the two fides of the body, and forming a very agreeable appearance, on account of the extreme whitenefs of a great number of blood-veffels, with which they are provided; and the colour of thefe veffels is greatly heightened by the greenifh hue of the gills through which they run.

Examining one of thefe gills, I found in only half of it more than forty divifions or ramifications of the greater blood-veffels; that is more than eighty to a fide. But if we confider alfo the prodigious number of thefe ramifications, which penetrate into the fubftance of the gills, Fig. i. *k*, where the mufcles adminiftring to thefe parts likewife run, we fhall have reafon to think

think the number of thefe ramifications is almoft infinite.

Words cannot do juftice to the contrivance, order, invention, and moft elegant conftruction of thefe parts; fo that my figures deferve only to be confidered as the faint fhadows of their perfection. The gills are membranaceous underneath, near the roots, where they end in a flender ftalk, as it were, and are faftened, as appears, by a pretty ftrong ligament, *l l*, though as yet, I am not fure but this ligament itfelf, may be compofed of blood-veffels, not having had fubjects enough to examine thefe parts fo much as they deferved. On opening the divifions of the gills, this ligament makes a pretty appearance; at the fame time, that we may difcover how thefe parts grow more and more flender towards their roots, *m*.

Indeed the conftruction of the gills is more apparent in other kinds of fifh, whofe blood is red; for in fome we meet with cartilages, and in others real bones, over whofe furface the blood veffels are diftributed. This circumftance I formerly moft evidently difcovered in the Sturgeon, the Whiting, and other fifhes, by injecting their blood veffels according to a method peculiar to myfelf, and of my own invention. This I could difcover, and I faw it with the greateft aftonifhment, that the contrivance, ftructure, and order difplayed in thefe parts by the fupreme Architect, and difcoverable by thofe who love to contemplate Him in his works, were infinite in perfection and number, as I fhall hereafter endeavour to prove by defcribing and delineating fome of them by way of fpecimen of the reft. In the mean time, I can fhew the curious the parts themfelves injected by me with wax of feveral different colours.

In that part of the Cuttle-fifh's body, which I confider as the thorax, there is a protuberance, Tab. LI. Fig. I. *n*, by naturalifts called mutis. Upon this part there is always found lying an open pipe, quite loofe, fo as not to be confined to any one place *o*, but floating freely in the body. This pipe is, properly fpeaking, the animal's rectum, or ftraight gut. It has alfo a remarkable aperture at its end, by which the fifh difcharges its inky liquor from the bag contrived by nature to contain it. This bag lies in the lower region of the belly, where it fhews itfelf thro' the tranfparent interpofing parts *p*. Near the lower part of the ftraight gut there are two more fhort, open-mouthed tubular channels *q q*, for the difcharge of the feminal matter, the veffels of which lie under thefe channels, with an extuberant membrane between them *r*. Lower down in the ftomach *s*, and under the ftomach, a certain little particle or body *t*, belonging to the fpermatick veffels, fhews itfelf thro' the tranfparent parts that lie over it.

In that part of the body where the extremity of the ftraight gut floats loofely on the right, there is on the left another loofely-floating tubular aperture *u*, thro' which the tefticle itfelf difcharges its fperm, which is afterwards to be carried off into the water, thro' the common excretory duct. This tefticle is placed with its vas deferens, on the left fide under the gills *x*, and fhews itfelf faintly without diffecting the parts that cover it.

It is now time to give a more complete enumeration of all the parts hitherto mentioned, with a fuller defcription of them; and the figures will make it ftill more intelligible: this I fhall do, after having firft taken fome notice of the parts of the Cuttle-fifh belonging to its head, which lies upon the back. It is here that we fee its beak, and the mufcular circumference of its mouth *a*, which I have here reprefented a little lefs than nature; but in every thing elfe perfectly agreeable to the life. But, not to make my drawings too large, I have taken the liberty of curtailing the legs, and the two arms in this figure *ββ*, which I have exhibited in their natural fituation and pofture. I have likewife taken great care to fhew exactly in what order the acetabula are placed on the two forelegs, when the mufcles of thefe acetabula are contracted; for it is an eafy matter to procure a fight of them in this ftate, even in a dead fifh. This is done by cutting fome of them off, with part of the leg to which they belong, and then dipping the whole in boiling water; for in lefs than a minute they become perfectly contracted.

I likewife give a drawing of thefe mufcles with their acetabula, as they appeared at the extremity of one of the arms, which I had ftripped of its internal fkin; fo that their infertion and conftruction, Tab. LI. Fig. II. *a*, may, by this means be very diftinctly feen, as likewife the order in which the acetabula themfelves are united with their mufcles *b*. It likewife appears by this figure, that both the acetabula and their mufcles, are much larger about the middle of the arms than at either of their extremities *c c*.

I have thought proper to reprefent in a fegment of one of the larger legs, that lie over the head, Fig. I. *γγ*, the internal ftructure of the legs themfelves. Their texture on the outfide is fibrous and mufcular; but within-fide it is a little more fungous. In the middle of them there appeared fomething that I took for a blood-veffel, and I have here reprefented by a black dot *δ*.

To take a furvey of the Cuttle-fifh's infide, it is neceffary to cut away the common excretory duct, and the mufcles which move its two acetabula, and then very cautioufly to open that part which I call the thorax, and raife from it its membranaceous covering. This done, there appears the loofe fungous body, called mutis by naturalifts, and thought by them to have a great refemblance to the liver. I have always found this mutis regularly didivided into very diftinct parts. The upper part is very thick, and with gentle treatment it may on each fide be eafily parted into two lobes, Fig. III. *a*. Otherwife, on wounding the coat that invefts it, its fubftance readily flows off, being exceeding foft, and like a liver bruifed by an anatomift, in order to extract its parenchyma,

parenchyma, or pulpy ſubſtance. In the middle this mutis is very thick and ſpungy, and at its lower extremity conſtantly ends on each ſide in an obtuſe appendage *b b*, which extends to the belly. The upper end of this organ lies in part on the throat, which lies itſelf alſo on the ſalival glands, Fig. V. *b b*, and thus runs under the mutis to the ſtomach. Under the throat appears the great artery, which riſing upwards from the abdomen (where this animal's heart lies) ſends to the mutis two conſiderable branches, Fig. III. *c c*, that iſſue from thence, as if they deſcended from the thorax. The greateſt part of this body lies upon the bone of the fiſh, on each ſide of the bone, and of the great artery, and it is only divided from the bone by a kind of fibrous membrane.

After this, the courſe of the blood-veſſels running thro' the mutis, is diſcovered by opening and turning over, Fig. III. *d*, the membrane that encloſes it. But the ſubſtance of this part is ſo very ſoft, that by expanding itſelf like a liquid, it intirely hinders the view. This makes it neceſſary to ſeparate with a ſpatula this pulp from the veſſels that go thro' it, and afterwards thoroughly waſh the veſſels themſelves with water. Thus, at length, a ſatisfactory ſight may be obtained of the diſtribution of the blood-veſſels, Fig. IV. *e*. By this proceſs we likewiſe diſcover that the ſubſtance of this part is in a manner entirely compoſed of an infinite number of little grains, being looſely connected with the blood-veſſels *f*; but then a good microſcope is requiſite to diſtinguiſh theſe ſmall corpuſcles. The colour of the mutis is between red and yellow, ſomewhat inclining to a brown. I cannot determine what the uſe of it may be; it lies entirely by itſelf, within a peculiar membrane, and conſiſts of two diſtinct bodies, without having the leaſt reſemblance to the liver, as heretofore idly pretended. Nevertheleſs, I cannot take upon me to deny its performing the ſame office with the liver, as the wonders of nature are inexhauſtible, and God the maſter of nature has, in different animals, formed in a various manner organs ſubſervient to the ſame purpoſes; this will evidently appear by the ſurpriſing ſtructure of the genital parts of this animal, which are contrived with an art and elegance that ſurpaſſes all deſcription.

The throat, as I ſaid before, runs under the mutis, and has its origin in the ſame place nearly where the fauces terminate. By the fauces, I mean that wrinkled and muſcular part of the ſkin, which reaches from the beak and mouth, Fig. V. *a*, to the beginning of the gullet, or that tube which runs from the mouth to the ſtomach. This gullet paſſes under the brain, and then deſcending into that part of the body, which I call the thorax, it there lies ſoftly upon the ſalival glands *b b*, and is connected with the two already taken notice of; from whence it runs in a ſtraight line to the abdomen, where it opens into the ſtomach *c*. The ſtomach reſembles in a manner a ſpherical bag; but it is ſomewhat indented in the middle. There run thro' it a great many blood-veſſels *d*, which are ſeen the better by injecting the arteries with ſome coloured liquid. This organ conſiſts of three coats; the external coat is membranaceous; the middle coat muſcular; and, as to the internal coat, it readily ſeparates from the middle coat with the food it immediately encloſes, and ſo may be eaſily taken out of the ſtomach with all its contents.

The Cuttle-fiſh, I could obſerve, feeds upon Shrimps; for there remained in its ſtomach the eyes, legs, and tails of Shrimps, with ſome of the rings of their bodies. I could diſcern among theſe, remains of the back-bones and ribs of ſome very ſmall fiſhes.

The ſtraight gut, Fig. V. *e*, iſſues immediately from the ſtomach, and is the only inteſtine I could diſcover in this animal; ſo that the veins muſt take the aliment immediately from the ſtomach, and then convey it to the heart, whoſe buſineſs it is to diſtribute it over the whole body.

Under the ſtraight gut lies an appendage of the ſtomach, into which it opens by a particular orifice, after twiſting like a ſnail in a very remarkable manner *f*. I cannot ſay for certain what this part may be; tho' to judge anatomically of it, I ſhould take it for the pancreas, which, except its not being twiſted, appears of the ſame conſtruction in a great variety of fiſhes, as may be ſeen in a treatiſe of mine on that part of the creation, adorned with figures, printed by Commelyn of Amſterdam, and dedicated to the College of Phyſicians of that city. This organ is very ſmooth and ſlippery on its inſide, and contains a matter like the pancreatick juice of other fiſhes.

The white bag which contains the Cuttle-fiſh's ink *g*, lies principally in the left ſide of the body, and communicates by a ſlender channel with the upper extremity of the ſtraight gut *h*; ſo that both the fæces and the ink are diſcharged thro' the ſtraight gut by one and the ſame orifice. This bag is in part membranaceous, and in part muſcular; and is furniſhed with blood-veſſels, which run over its ſurface *i*. Within I diſcovered a little glandulous body, or maſs, which perhaps ſerves to generate or prepare the ink; for I had not opportunity to examine it thoroughly, on account of the ink's flowing ſo conſpicuouſly, that it was impoſſible to waſh it off faſt enough to obtain a ſatisfactory view of this organ.

It is therefore neceſſary not to wound this part on diſſecting the Cuttle-fiſh, as by pouring out its contents it would infallibly render all the other parts inviſible. The ink contained in one bag is ſufficient to communicate a blackneſs to ſeveral pails of water, ſo intenſe is its colour. I ſhall not pretend to ſay abſolutely what the uſe of this ink may be; or whether or no it may ſerve to obſcure the ſurrounding waters, and thereby ſecure this animal from other fiſhes which would devour it; for, as yet, I have had no experience in this matter. But it is certain that the Cuttle-fiſhes I found dead

dead on the fea-fhore contained a greater quantity of this ink than thofe which were brought to me alive. The liquid is infipid to the tafte, without the leaft fowernefs or bitternefs; fo that I cannot fee how this infipid fubftance, by being boiled with the Cuttle-fifh, can in the leaft contribute to give it an extraordinary relifh, as thofe pretend who feed upon it; tho' the moft general manner of ufing this fifh; is barely to give it a drying in the open air.

The ink taken out of its bag, and poured into a glafs coagulates and grows hard in a few days, when it feparates into a great many little pieces, which, ground upon a ftone, afford the moft elegant black paint. This convinces me that the Indians prepare their ink with nothing but this juice. I have even obferved that this fubftance, while in a liquid form, ftruck fo ftrong a black, that no wafhing could get it out; as particularly appeared in a black coat made of a flight dutch cloth, which had fome yellow ftains from aqua fortis: near the ftomach, and between the folds of the pancreas, there lies a glandulous body, which runs to the throat, Tab. LI. Fig. V. *k k k*; but I am as much in the dark, as to its ufe as to that of the ink-bag; tho' I think it belongs to the organs of generation, which I fhall hereafter take notice of, having firft defcribed the heart, brain, and nerves; and likewife faid fomething of this creature in particular.

The heart of the Cuttle-fifh, contrary to what we obferve in moft other animals, lies in the abdomen, Tab. LII. Fig. 1. *a*. It is of an oblong triangular form, and in colour very like a mufcle that has neerly loft all its blood. Its external furface is tolerably fmooth and even, and its internal one fibrous, and divided into little hollows, and prominent columns. I could difcover but one ventricle in this organ.

The Cuttle-fifh's heart has two auricles; for as the gills in this animal are placed on each fide of the body, and at a great diftance afunder, nature it feems, has thought proper that, inftead of one, this fifh fhould have two auricles *b b*, which I have here reprefented, as they appeared on feparating them from the blood-veffels of the gills *c c*. They are of a membranaceous texture, and, when blown up, are of the fame figure exactly with the defign I give of them. I have no more at prefent to fay of thefe parts; for they had almoft efcaped my notice when I happened to difcover them; fo that to acquire a thorough knowledge of them, I fhould have had more fubjects; which are not to be obtained without great trouble and expence, on account of the brutality and avarice of the fifhermen, who fell the produce of their hardeft labours for nothing in a manner, whilft they fix an extravagant price on fuch things as come in their way without their being at the pains to look for them. In the mean time I muft obferve, that this fifh's heart having but one ventricle, at the fame time that it has two auricles in common with other animals, is altogether fingular, and may well deferve to be confidered as a paradox. The blood of the Cuttle-fifh is white, which is all I can fay of it, as I never examined it; tho' I had refolved to fave fome of it in a glafs tube for microfcopical infpection, and in order to find out its analogy to the red blood of other animals.

The great artery, which firft rifes from the heart *d*, is of the fame conftruction with that of fifh; but it grows fomewhat fmaller in its courfe, and fends forth two pretty confiderable branches, which immediately difpatch lefs ones *e e* to the mutis, whilft the others run to the mufcular parts of the reft of the body; fo that fome of thefe ramifications are feen plainly thro' the tranfparent fkin under the two mufcles, which move the acetabula of the common excretory duct, Tab. LI. Fig. 1. *y*; from whence they extend to the gills and feveral other parts. After this the artery formed into one trunk, ftretches to the bafe of the brain, Tab. LII. Fig. 1. *f*, where it divides into various branches, fome of which run thro' the cartilages, that enclofe the brains in place of a fkull, whilft the reft diftribute themfelves to the legs and other parts of the body. But it is yet unknown what is the courfe of the veins in this creature, and whether it has like fifhes a firft and fecond artery, thefe are things I have not yet been able to difcover; neither can I tell for certain, whether or not the two veffels fpringing from the lower region of the heart itfelf *g g*, and here moft exactly reprefented by me after life, are really veins, as I think they are. But all thefe doubts may be cleared up by repeated diffections.

The brain of the Cuttle-fifh is very fmall, and is plainly divided into a right and left portion, Fig. II. *a* To fee this conveniently, it is proper to turn the animal on it's belly, then open its head, and cut away with a very fharp knife the cartilages that contain the brain, ufing great caution for fear of injuring the nerves which iffue from it. The brain lies on the back part of the head, in a manner entirely buried in fat, which I have here for diftinction fake reprefented by dots *b*. It is no eafy matter to feparate this fat on every fide without hurting the brain on account of it's exceeding foft and delicate texture. The optick nerves *c c* are likewife at their origin furrounded with fat; but in their progrefs, after running thro' the cartilages of the brain, they dilate into a confiderable knot *d d*, which feparating into two tubercles, as it were, fends thence towards the eyes a great number of nerves *e e e e*, as I have endeavoured to reprefent them one fide. This numerous body of nerves is interfected by a confpicuous blood-veffel *f*, before they can reach the choroide tunic, or coat of the eye; which is remarkable for its great variety of beautiful colours; and is fo invefted with thefe little fibres, which embrace and furround the eye on every fide *g*, and have a great fhare in compofing it, that this ufeful organ muft receive great ftrength from fuch an acceffion. About the upper region of the eye, where the iris fhews itfelf in other animals, this coat forms in this a globular prominence *b*, from which a cryſtalline lens partly projects *i*.

I have thought proper to give a ſeparate drawing of the pupil's covering or lid, continued to the extremity of the choroide tunic; I firſt repreſent it on that ſide where it was cut from the eye Fig. III. *k*, and looks of a deep green colour, which by degrees grows paler, and is interwoven with delicate veſſels. I then exhibit its other ſide, by which it may be ſaid to float freely in the aqueous humour, and reſt againſt the cryſtalline lens. In this part it is of a ſilvery whiteneſs, and interſperſed with very delicate ſtreaks or fibres. Theſe fibres look as if they were continued not only to the filaments of the iris, but likewiſe to thoſe of the choroide tunic, which I have already repreſented. This covering or lid of the pupil is of an extreme blackneſs in that part of it, which lies over the ſuperior region of the cryſtalline lens.

I could find but very little of the aqueous humour on the inſide of the eye, whereas that conſtituting the cryſtalline lens was in conſiderable quantity, and was tolerably compact. But there was ſomething ſingular in this laſt part, namely, its coat's being of an extraordinary thickneſs, and likewiſe its ciliary ligaments penetrating ſo deep into the cryſtalline lens, that it in ſome meaſure as it were divided this part of Tab. LII. Fig. IV. *m*, the eye; this may be beſt ſeen on the fore part. On boiling this eye, and then pealing off the ciliary ligament, along with the coat of the cryſtalline lens; and likewiſe the fore ſegment of this lens from its back ſegment, the lens itſelf appears exactly like a globe contained in a ſemi-globe, or like a ſphere in a hemiſphere.

The vitreous or glaſſy humour was in a manner ſo perfectly fluid, as rather to deſerve the name of an aqueous than vitreous humour. I could not diſcern exactly the retina, as the black juice of the avea happened to get out of its membrane, and thereby ſpread an impenetrable obſcurity all over the adjacent parts. This accident for want of ſubjects, obliged me, to put an end to my anatomical ſurvey of the eye; and therefore I ſhall return to the brain, and the nerves that iſſue from it.

From the fore region of the brain, there ariſe three conſiderable pairs of nerves, which, after making their way thro' the cartilages of the brain, run in a moſt beautiful manner to the muſcles of the head, beak, legs, and adjacent parts. But the conſtruction of the middle pair is more admirable than that of the lateral ones, as it ſwells into a node or globule Fig. II. *n*, from which the nervous branches iſſue in a moſt elegant manner, like rays of light of the ſun's body.

The better to ſhew the ſituation of all theſe parts, I have given a particular engraving of the cartilages which ſurround the brain *o o*, as well as thoſe ſerving for a foundation or prop to the eight legs, *p p*, in the center of which lie the mouth and the beak. From the back part of the brain iſſue two very large nerves, *q q*, which form each of them a remarkable knot, *r r*, after having paſſed through the thorax, and under the muſcles that ſerve to move the acetabula of the common excretory duct. I could count more than twenty little nerves, which ſprung from each ganglion, and were diſtributed to the region of the gills; after running on each ſide of the acetabula, of the common excretory duct, where they in part ſhewed themſelves through the tranſparent ſkin, Tab. LI. Fig. I. *z*.

The genitals of the male Cuttle-Fiſh may be divided into three parts, one teſticle, and two glandulous parts, between which there lies another glandulous body, divided into a great many lobules; and laſtly, a peculiar glandulous and ſpungy body, in ſhape like a heart, ſeated under the animal's ink bag.

That part, which I call the teſticle, on account of its external appearance, is ſo admirably contrived, that it greatly ſurpaſſes all the wonders I have hitherto related of the Cuttle-Fiſh. It ends in a particular open-mouthed tube, which floats looſe in the body, like the end of the ſtraight gut, *u*. It is through this tube the teſticle diſcharges its ſperm, ſo that it may very properly be called the vas deferens of this organ. I could ſometimes obſerve ſome very tender and delicate white fibres hanging from this part, Tab. LII. Fig. V. *a*; but I cannot ſay whether they were natural, or were occaſioned by ſome diſorder in the animal, as I never examined them in a live one. This ſingle teſticle is oval, but it ends at the bottom in a kind of a point, *b*. In the centre of it there is a little body, which very nearly anſwers the paraſtatæ, or corpora variaformia of quadrupedes, and even of man, *c*; but I have not yet been able to diſcover where this veſſel begins or ends. The nearer this little body, juſt taken notice of, approaches the teſticle, the broader it grows: this circumſtance may be beſt ſeen, by turning the teſticle upſide down, and then diveſting it of the great number of membranes which cover it, *e*. I have ſome reaſon to think, that the whole teſticle may be unfolded, and wound into one long veſſel, ſomewhat ſlenderer at its beginning and at its end, than in the middle, and terminating in a curious curled little tube, *d*. The texture of the genital parts already mentioned, is glandulous. In the narrow parts of the channel juſt now ſpoke of, there is found a white ſpermatick matter, which, on wounding this part, iſſues forth in form of coagulated milk; but the ſubſtance contained in the ſomewhat wider parts, is tranſparent: the wideſt parts of all are full of an infinite number of little delicate white parts, ſomewhat crooked, which are altogether free and looſe at their hinder ends, Tab. LII. Fig. VI. *f*; but at their fore ends, they terminate each in a very delicate filament, *g*, by which they are in a manner linked to each other. Theſe delicate fine threads may be unwound, to double the length of the other parts to which they adhere; and on taking both the threads and theſe parts into the open air, the former immediately harden like the threads drawn from ſilk Worms, and ſhine and glitter like a looking glaſs.

The moſt ſurpriſing circumſtance in this part is, that on throwing ſome of theſe into water, they, after a little time, begin to move, and then open-

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ing at their hinder, and fometimes at their fore, extremity, they fuddenly difcharge a little white body, which, on its efcape, rolls and curls itfelf up in a ferpentine manner, *h*, the larger part, all the while continuing in its former ftate, without the fides of it falling together. This furprifing little body, when viewed with the microfcope, looks like a very white Earth-worm, divided into a great many exceeding fmall rings; and if left in the water for fome time, it expands and grows bigger by degrees, by the water it imbibes, which makes me imagine, that the water may poffibly be the caufe of that wonderful motion obfervable in thefe parts, on their being put into it.

Thefe particles, when thrown into fpirit of wine, remain perfectly quiet, without any opening.

Thefe parts may be very diftinctly feen thro' the tranfparent coats of the tefticle; and they appear divided into a great many rows. Sometimes even they may be obferved to have rolled themfelves into ferpentine coils, and difcharged their white particles, before the tefticle has been opened, Fig. v. *i i*.

On examining with the microfcope one of thefe minute parts, we may plainly perceive its conftruction, and can fee a tranfparent fpace, like an air bubble, at its hinder end, Fig. vii. *a*. A little higher up is the region, within which lies the little furprifing moving white particle, juft now fpoke of, *b*. But I have here reprefented it much fhorter than it appears through the microfcope, for fear of enlarging the drawing to too great a fize. This little part grows tranfparent again near its fore end, Fig. VII. *c*. But the fore end itfelf is very neatly curled, *d*, and it is from this extremity that the filament iffues, which hardens in the air, like the Silkworm's thread, *e e*.

Whether thefe filaments be hollow, and whether the fperm be generated in the cafes which contain them, as in fo many kind of feminal tubes, or whether all the cafes themfelves, with their contents, be difcharged by the animal at the time appointed by nature, for its fhedding its fperm, are very obfcure queftions, which as yet I am not able to anfwer *. Let it therefore fuffice, that I have juft exhibited, to the glory of the Great Architect, the admirable beauty and con-

* The public received fome few years fince, an account of thefe veffels in a fpecies of Cuttle-Fifh, from the ingenious Mr. Turberville Needham: but we fee the firft account of them is owing to this author; and much is yet to be expected in the perfecting their hiftory, from fome future philofopher accuftomed to thefe inquiries, who fhall have opportunities of obtaining the animal alive. The fpecies mentioned by Mr. Needham is, as we have before obferved, the Loligo of authors; and his obfervations on the conftruction and action of thefe particular parts, is this——

The outward tranfparent cafe is cartilaginous and elaftick: its upper extremity is gathered into a round head, which is in reality nothing more than the top of the cafe involuted into itfelf, and by that means clofing the orifice, through which the interior apparatus fprings in the time of action.

Within this is contained a tranfparent tube, elaftick, as it appears from the phenomena, in all directions, and forcing its way where-ever it finds a paffage, which tho' the continuation of it is not equally fenfible in all parts, may be eafily difcovered in a courfe of experiments to inveft the fcrew, fucker, barrel, and that fpungy fubftance, which imbibes the femen. The fcrew is inferted in the upper part of it, and throws out of the head of it two flender ligaments, which faften it with the whole annexed apparatus to the top of the outward cafe; the fucker, and barrel or cup, are lodged in the middle of the tube, and the fpongy fubftance containing the femen diftends the lower part.

I fhall now proceed to the feveral phænomena's that appeared in the action of this minute machine, which to me at leaft feemed fo furprifing and inexplicable, that I think myfelf obliged to premife, that I am in no wife anfwerable for any feeming contradictory confequences, which may poffibly be drawn from matters of fact I dont pretend to account for: all I can affure the public of, is, that they are literally true, juft as they are related, and were feen by feveral perfons, as well as myfelf. The objects I have now by me preferved in fpirit of wine, which, though they retained their activity for more than twenty days after they were taken out of the fifh, and immerfed in fpirits, without any fenfible diminution, yet now have in a manner totally loft it, though they remain to all appearance in the microfcope perfectly the fame. If therefore any of my readers defire to verify the facts I have mentioned, they muft apply in the feafon for frefh objects, and do their utmoft to procure the milt-veffels when perfectly ripe for action; for thefe only will anfwer to all the phænomena I have taken notice of, though the lefs mature will fuffice for moft of them.

Tho' many of the milt-veffels, when they are ripe for action, and difengaged from that glutinous matter which furrounds them while they are in the milt-bag, will act immediately in the open air, for which perhaps the flighteft preffure during extraction may be fufficient, yet the generality of them will not only bear a tranflation to the object-plate, and lie quiet for obfervation, but alfo require a drop of water to moiften the upper extremity of the enclofing cafe, before they begin to operate.

Upon application of this, the extremity begins to evolute and unfold itfelf, and the two flender ligaments, which emerge out of the cafe, turn and twift themfelves in various directions: at the fame time the fcrew moves upwards with a flow motion, the fpires at the top gathering clofe together, and acting againft the head of the cafe, while thofe at the bottom advance proportionably, and feem to be continually fucceeded by others out of the head of the pifton; which fucceffion I believe to be apparent only, and not real, the appearance being owing to the nature of the motion in the fcrew: in the interim, the fucker and cup, or barrel, move gently on in the fame direction; and the inferior part of the apparatus, which contains the femen, extends itfelf in length proportionably, with a motion at the fame time upwards, which may be perceived by an increafe of the vacuity at the bottom of the cafe. Soon after this, the top of the fcrew, with its enclofing tube, appears out of the head of the cafe, and as it is there faftened by its ligaments begins to bend: the motion of the whole continues thus flow and gradual, till the fcrew, fucker, and cup have forced their way, and emerged totally, when at that inftant the remainder of the apparatus fprings out at once, the fucker feparates from the cup, the feeming ligament below the cup fwells out to the diameter of the inferior part; the inferior part, though diftended confiderably in breadth, more than it had been in the cafe, extends itfelf to five times its original length; two knots, between which the tube contracts itfelf in diameter, form themfelves, each at about the diftance of one third of the whole from both extremities, and the femen flows out of the cup, confifting of fmall opake globules fwimming in a fort of ferous matter, juft in the fame form, and without any appearance of life, as I had feen it before, when diffufed at large in the milt-bag. After the operation, it is to be obferved, that the fringed edges between the two knots appear upon examination to be nothing more than the interior fpongy fubftance broke and disjoined at almoft equal diftances, as will be clear from the fubfequent phænomena.

Sometimes the fcrew, together with the tube, breaks juft above the fucker, and the fucker remains in the cup, of which I have alfo given a drawing: in that cafe the invefting tube clofes inftantly at the extremity of the fcrew, as far as it will permit, and contracts itfelf nearly in a cone, which plainly indicates its great elafticity in this, as its conformation to the fhape of the enclofed fubftance upon the leaft change does in every other part.

At firft view, an obferver would be inclined to think, that the action of the whole machine is to be derived from the fpring of the fpiral fcrew; but the following experiments, which I tried with a view of fatisfying myfelf in that particular, not only evince the falfehood of that fuppofition, by demonftrating that the fcrew can at moft act but as a counter to a force entirely latent, but afford a train of phænomena fo furprifing, that they totally filenced all the hypothefes I was capable of forming. The experiments were tried upon milt-veffels, which though not fufficiently mature for the ejection of the fucker, dilatation of the feeming ligament below the cup, and the expreffion of the femen, had already attained the full force requifite for the exertion of the interior apparatus out of the enclofing cafe; thus they completely anfwered my prefent purpofe, as well as the moft mature could, and remedied the misfortune I had of lofing the only parcel of mature milt-veffels I have found in the courfe of my inquiry, which I had laid by for further obfervation.

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contrivance of theſe parts; contented as I am in being thought ignorant of every thing elſe belonging to them.

As to the other parts, compoſing in my opinion, the organs of generation, the conſtruction of them is very remarkable; for they ſeem as it were to conſiſt of two diſtinct glands, placed at the ſides of the abdomen, and there connected with the gills, Fig. VIII. *aa*, from which I ſeparated them. Theſe glands are white, and there adheres to each of them another glandulous body, by means of a glandular tube, in form of a ſtalk *bb*. Theſe corpuſcles are of a ſomewhat grayer colour than the reſt, and have each of them a conſiderable ſlit, with a great many little openings at the bottom, through which iſſues the ſeminal matter formed in theſe and the inferior particles.

This ſeminal matter, after flowing from its glands, is conveyed to a bag that lies at one ſide, and is repreſented under the letter *r* of Figure I. Tab. LI. from whence it is diſcharged out of the body by two diſtinct tubes. The mouths of theſe tubes appear very plain at the ſides of the ſtraight gut; and the matter they contain, may even be ſqueezed out of them. Theſe tubes are exhibited in the figure and table laſt mentioned, under the letters *qq*. But I cannot as yet take upon me to ſay whether or no they ought to be called the proſtaſtæ, or what other organs they may properly be.

Among the parts I am deſcribing, there lies a glandulous body divided into lobes Tab. LII. Fig. *c c*, VIII. and connected by means of ſome delicate membranes *dd*. Theſe lobes are again moſt beautifully divided, as it were, into a great many branches, covered with tender, and in ſome ſort membranaceous, glands, which in the animal itſelf forms a moſt entertaining ſpectacle. From this body there ariſes, on preſſing, another kind of ſpermatic matter. The lobes laſt mentioned, and their glands, are of different colours, partly white, and partly inclining to gray; the glandulous body itſelf alſo, which I heretofore repreſented as adhering to the ſtomach, ſeems to have a communication with theſe glands; for as yet I cannot take upon me to affirm poſitively, that it has any. I muſt have more ſubjects to examine, before I can determine any thing in regard to this and ſeveral other particulars relating to this Cuttle-fiſh. The beſt time to take a thorough ſurvey of the creature, would be when the ſperm is not as yet arrived at its full maturity. But ſuch a ſurvey would require a great deal of attention and leiſure.

The third part belonging to the ſpermatic veſſels has been already exhibited, as it appears through the tranſparent ſkin under the letter *t*, in the firſt figure of Tab. LI. Fig. I. It lies in the lower region of the abdomen, under the ink bladder. It is of a glandulous ſpungy ſubſtance, and contains a ſeminal matter, which may be eaſily preſſed out of it. Its ſuperior region is ſomewhat broad, flattiſh, and depreſſed, Tab. LII. Fig. IX. *a*; the inferior terminates in a manner in a double or forked point *b*, ſo as in ſome degree to reſemble the ſhape of a heart. I cannot ſhew the channel by which this part diſcharges its ſpermatic matter, as I tore and broke it, on ſtriving to take it out of the creature's body.

I could not at this time narrowly inſpect the genital organs of the female Cuttle-fiſh, becauſe I wanted a ſufficient number of ſubjects; and thoſe, in which I obſerved all the particulars hitherto related, were both males. For this reaſon I cannot now take upon me to give a ſatiſfactory account of the parts viſible in the female, or to ſay whether or no it has any genital organs anſwering to thoſe, I have already deſcribed and delineated, as belonging to the other ſex. I ſhall therefore attempt no more at preſent, than juſt to give a drawing of the genitals of a female Cuttle-fiſh, which I ſome years ago took care to prepare and preſerve, referring to ſome other time, when I ſhall have inclination and leiſure to perform ſuch a taſk, a thorough ſurvey of theſe parts.

The firſt thing I here repreſent, is the ſtraight gut *a*, Tab. LII. Fig. X. to the ſide of which adheres the channel by which the ink is diſcharged *b*. The ink bag itſelf *c*, lies upon the ovary *dd*. At the other ſide of the ſtraight gut

If the milt-veſſel be divided juſt below the cup, that part which contains the ſemen extends itſelf inſtantly; and though a part only, and not the whole of it ſprings out at the opening, as it does not when ſevered from the reſt of the apparatus, yet upon application of water, it works itſelf out by degrees with a ſlow motion, and emerges almoſt entirely out of its caſe.

If the lower extremity of the outward caſe be cut off, it diſtends the ſeeming ligament below the cup to an inconceivable tenuity, breaks it without deranging the ſcrew, or cauſing any alteration in the ſuperior part of the apparatus, and goes out at the opening.

In one of theſe experiments, the ſeeming ligament breaking after diſtention, ſtruck with ſuch ſmartneſs the ſide of the encloſing caſe, that, though cartilaginous, its extremity forced its way through by its elaſticity, and retired twiſting itſelf again into the caſe; which can be accounted for no other way, than by ſuppoſing it extremely elaſtick, and its force upon this occaſion ſomething analagous to that of a ſilken thread, which, if ſuddenly emitted after diſtention, with a certain direction that it receives from a peculiar ſlight of hand, will open itſelf a paſſage through a ſheet of ſtrong paper.

If the milt-veſſel be divided both above and below the ſemen, it emerges at the two extremities, by extending itſelf in both directions, which being contrary to each other, detain it in the caſe with this additional effect, that it renders the encloſing tube conſpicuous, by ſevering aſunder at ſome of its diviſions the ſpongy ſubſtance which contains the ſemen. I mean by diviſions the rings throughout its whole length, reſembling thoſe of a Worm, though not ſo regular, as they appear through the greateſt magnifier of the common double reflecting microſcopes; yet, with the third magnifier, from which theſe drawings were taken, they are ſeen as exhibited in the figures, like a fringe inveſting the edges. I have ſometimes upon this occaſion counted no leſs than nine ſeparations, though no more than four appear in the drawing; for in this particular, there is no determinate regularity.

If the leaſt orifice be opened with a lancet in the ſide of the outward caſe, it inſtantly conforms itſelf to it, and comes out double.

'Tis obſervable alſo, that the ſcrew, upon ſeparation, ceaſes in every reſpect to operate, and loſes irrecoverably its activity, which is an evident proof, that the whole force of the milt-veſſel is to be derived from the action of the inferior part.

The application of water is for the moſt part neceſſary, and yet the milt-veſſels will often act without it: ſpirit of wine will alſo ſuffice, though the effect is conſiderably ſlower, and the ſpring, with which the inferior part at the cloſe of the operation, when regular, ſuddenly ſtarts out, is totally impeded; but this was underſtood of a ſingle milt-veſſel placed upon the object-plate; for when the whole bag is immerſed in ſpirits, even ſo that the liquid has free acceſs to the whole collection, it cauſes no other alteration, than that the inferior part is ſomewhat extended in length, and recedes ſome little from the bottom of the outward caſe. Oil has no manner of effect in any reſpect whatſoever, though more lubricating than any other liquid.

is an open-mouthed tube or duct *e*, by which the eggs are voided. I here exhibit three of thefe eggs *f*, one half lefs than the natural fize. Upon the ovary and ink bladder are placed two very beautiful glandulous bodies, reprefented at *gg*; but I cannot now fay any thing certain concerning them, as moft of my former obfervations are only recorded by drawings, with a bare explanation. Above thefe two bodies, or rather in the midway between their appendages, appears a remarkable little bladder or bag, which contained a red juice *h*. Laftly, I exhibit at one fide all the parts already mentioned, and the gills *i i*, together with their veffels and divifions, in their natural fituation.

I fhould here finifh this effay, if for order fake I did not think it proper to add fomething concerning the Cuttle-fifh's bone, being the only one to be found in the body of this wonderful animal. The flefh clofely furrounds this part on every fide, in the manner obfervable in man and other animals. To obtain a fatisfactory fight of it, no more is requifite than to make an incifion in the fifh's back, and feparate the bone itfelf from its membranes, and other integuments; all which may be very eafily performed.

This bone, when newly cut out of the animal, is of a middle nature between a dry and a moift fubftance; it floats upon the water, if immediately thrown into it. And this, no doubt, is the reafon of its having been called fpuma maris, or fea-froth. Hence alfo it happens, that fo many of thefe bones are feen during the fummer months floating near our coafts, upon which they are at laft thrown, in proportion to the number of Cuttle-fifhes that have died fince the preceding feafon. The fifhermen gather thefe remains, and fell them to the different tradefmen, who have occafion for them. It would take me up a large volume to defcribe all the wonders obfervable in this bone, in regard to its figure, colour, texture, and other qualities; I fhall, therefore, only juft account in a few words for its floating on the furface of the water.

This bone which lies in the animal's back, on breaking it, after having firft cut with a file thro' the hard cruft that covers it, fome inches from its fore end, appears to confift of feveral teftaceous plates *a*, Tab. LI. Fig. VI. Of thefe the upper ones are the longeft, and moft crooked; and they lie clofer to each other than the lower ones, which being applied to the hard cruft of the bone that had been filed off, yield fomewhat in length to the former. The reafon why the lower plates fhould lie loofer, or at a greater diftance afunder, than the upper ones, feems to be this; that the former have received more nourifhment during the fifh's time of growth, than the latter, and therefore increafed in bulk a great deal fafter. Befides, the hard cruft of the bone, by lying nearer the upper plates than the lower ones, is fufficient to make the former full amends for fuch a deficiency.

Between thefe plates there are a great many filaments reaching from one plate to the other, like fo many props or columns, fo as to hinder the plates from clofing together. And the great lightnefs of the Cuttle-fifh's bone, in confequence of which it cannot but float like a froth upon the water, depends entirely upon this conftruction.

To make this very confpicuous, nothing more is neceffary, than to feparate two of thefe plates which lie at the greateft diftance afunder, from the adjacent ones; and this may be very eafily effected, by breaking with the point of a fmall pin, the filaments which unite thefe plates together, at the fame time that they keep them at a proper diftance afunder; for their filaments are fo fine and delicate, that they yield to the leaft impreffion.

On viewing with a microfcope the plates prepared in the foregoing manner, the difpofition of the columns or props *c*, between the upper and lower plates *de* immediately appears, as likewife their figure, and how they confift of a great many very fmall fibres which are compofed, as it were of minute globules. We may even obferve fome tranfverfe fibres, ftretching from one column to another, and fo ftrengthening them, and connecting them together. Befides, many of thefe props have a deeper foundation than the reft; and there is likewife a great variety in their figures.

To comprehend thoroughly the conftruction of thefe parts, and their admirable contrivance, it is proper to take a piece of the bone prepared in the manner juft now explained, and having faftened it in a fafe place, with a little ftarch pafte, leave it there till it dries. After this, care muft be taken to feparate the upper plate from the props fupporting it, without doing them any injury, which however difficult, I have often accomplifhed with perfect fuccefs. By this means it will at length appear, that thefe columns are fo many hollow flender tubes, Tab. LI. Fig. VIII. *g*, naturally full of air, which is a fufficient reafon, why the Cuttle-fifh's bone, when thrown into the water, fhould always fwim on its furface.

In this ftate, fome of the columns appear like perfect tubes, others of a lefs regular form, and many are beautifully bent, like paper folded in a variety of forms. This inflexion is very like that which we obferve within the noftrils of hunting hounds, in the bone upon which the fcent acts; as alfo, in horfes. This conftruction of the props cannot be perceived with the microfcope, till one of the adjacent plates is removed, otherwife they all appear cylindrical, becaufe they are tranfparent. For it is the property of that kind of glaffes to give almoft all hollow tranfparent bodies a round appearance.

The fubftance forming the cruft of thefe plates and their props, is in a manner of the nature of an alcaline falt; it ferments violently with acids. But on feparating from it the membrane, that covers the back part, it appears entirely compofed of the fame matter with the plates themfelves, and the interjacent columns, which makes it not improbable, that this ſtony and ſaline bone, found in the back of the Cuttle-fiſh, is originally compoſed of hardened membranes, and this conjecture is confirmed by conſidering attentively that part of the Cuttle-fiſh's bone, which lies within its tail, and the membranes inveſting it; for theſe laſt when examined with the microſcope appear of the ſame conſtruction with the plates and columns themſelves, But it is no eaſy matter to ſeparate theſe membranes; they are ſo firmly connected in that part with the hard cruſt covering the bone. When cautiouſly picked of, they leave a view of the manner in which this animal's bone grows at this place into a ſharp tale Tab. LI. Fig. XI. *b*, which in full grown Cuttle-fiſhes is much longer and more pointed, than in young ones, as in theſe laſt the membranes are not yet hardened. It may therefore be fairly concluded from all the foregoing particulars, conſidered together, that this ſtony bone of the Cuttle-fiſh, is formed in the ſame manner with the bones of men and quadrupedes. Nay, we can very plainly ſee that the blood veſſels not only run over the ſurface of this bone, but penetrate into its ſubſtance.

To cloſe this treatiſe, I muſt offer my moſt humble praiſes to the great Creator, for having made known to us ſo many ſpecimens of His inexhauſtible wiſdom, power, and goodneſs, all the glory of which we ought to give to his Divine Majeſty, praying Him at the ſame time to make us truly obedient to his will: ſo that we may henceforward do nothing but what is agreeable to Him, for in this exact conformity to His pleaſure our preſent and future happineſs entirely conſiſts.

THE END

A treatiſe on the Phyſalus *.

THIS creature, which Rondolet deſcribes from his own obſervations, and from Ælian, is found in the German ſea, and ſometimes is thrown aſhore on its coaſts in the ſummer months. I can produce one of them, which ſtuffed with tow, by a hole made in its back, and afterwards ſowed up, has its ſkin changed to a kind of real leather. I many times this ſummer ſpoke to the fiſhermen to get me one of theſe animals freſh, as they gave me to underſtand they often caught them alive in their nets, but as yet I have not had the good fortune to obtain any of them; I can therefore do no more at preſent than deſcribe it, and illuſtrate my deſcription with figures from ſome ſlight notes and drawings I formerly took of this creature; theſe obſervations, however, may throw great light upon what Rondolet has wrote concerning it, eſpecially what he has affirmed after Ælian of its ſurpriſing inflection. The Phyſalus when turned on its back, Tab. X. Fig. VIII. appears ſomewhat broad in the middle, on the forepart toward the head it is a little narrower, and at the tail it ends in a point. The abdomen is full of wrinkles, and is covered with a very delicate kind of biſſus or cottony matter. This creature has on each ſide of its body twenty eight protuberances, called by Rondolet dorſal warts, from which there ſpring very ſtiff briſtles *a a a*. The learned Oligerus Jacobeus, when here in Holland, made me a preſent of a creature of this kind, and called theſe briſtles its legs; but I cannot ſee any reaſon he could have for giving them that name, as the creature cannot uſe them as ſuch, tho' perhaps it may employ them as oars in ſwimming †. The Phyſalus has other protuberances beſides thoſe already mentioned; and except their being ſmaller and ſharper they are of the ſame conſtruction.

In ſome of theſe warts, which I cut from the creatures ſides, Fig. IX. *b*, I could count ſixteen briſtles diſpoſed inwardly into three rows, and united together in each row, by a particular ligament Fig. X. *c*, and all the ſixteen by another common one. The firſt row conſiſted only of two moderately ſtiff but very large briſtles *d*. The ſecond conſiſted of ſix *e*, and the third of eight *f*, differing in length, ſtructure, and firmneſs; all theſe briſtles were of a ſhining black, but there are other ſpecies of this creature, whoſe briſtles are of a bright gold colour. Such are theſe mentioned by Jacobeus in the *Acta Danica Medica*; and I have myſelf ſeen ſome of this kind. There are alſo Phyſali with green briſtles, if we may believe Rondolet, who calls theſe briſtles green hairs. Some of theſe briſtles, which give the creature a reſemblance to the Porcupine or Hedge-hog, appear thro' the miſcroſcope flattiſh and ſharp Fig. XI. *g*, whilſt others appear cylindrick, and ſomewhat thicker about their fore parts, Fig. XII. *h*, where they at laſt terminate in a blunt point.

Under the parts laſt mentioned, there grows on each ſide of the body a prodigious number of delicate gold coloured downy hairs. I have only repreſented thoſe on one ſide Tab. X. Fig. VIII. *i i i*, where the briſtles are omitted, to afford a better view of them; theſe delicate hairs ſpring likewiſe from the centers of certain warts, over whoſe ſurface they afterwards ſpread themſelves, Fig. XIII *k*. The laſt warts lie cloſe under the others ſupporting the briſtles, with which the hairy down growing in the form of flocks of wool is naturally intermixed, eſpecially on the upper

* This ſingular creature which former naturaliſts have univerſally called Phyſalus, and have been perplexed in what claſs to arrange it, Linnæus refers to his claſs of Worms, Vermes, he arranges it under the ſecond order; the creatures of which he entitles Zoophyta, and to this genus he gives the name of Salacia; by this denomination the creature is known at preſent among naturaliſts, and there is no other known ſpecies of the ſame genus.

† Theſe are not legs, nor intended for its office: they approach more to the nature of arms with hands or fingers; and are properly Tentacula of the creature: their uſe is in finding and ſecuring the creatures prey.

upper part of the body, and on the fides. The opening of the mouth lies forward near the head Fig. VIII. *l*, and over it is a little body refembling in figure and conftruction one of the beards that are to be feen in fome fifhes.

What has been faid, is fufficient to give the reader fome notion of this infects conftruction on its upper part or back, Fig. XIV. where it appears as if entirely compofed of an affemblage of downy hairs and briftles, the furface of this part alfo is rounder, and more convex, and the warts growing on it are fhorter and flenderer than thofe already fpoken of, as lying upon the parts, to which the name of feet has been given.

On opening the back of this creature, I found the fkin in that part lay quite free and loofe over the adjacent flefh. I likewife difcovered in this place on each fide of the body, a prodigious number of holes Fig. XV. *a a a a a a*, which by running a probe into them, I found to extend under and between the briftly tubercles, furrounding each fide of the body, with openings on the outfide, thro' which the creature by an alternate dilatation and contraction of its upper fkin, takes in the water requifite to moiften its gills *b b b b*, which are all the other parts to be feen within this hollow of the fkin, and are conftructed like the fcales on the lower part of the bellies of Serpents. As to their texture it is membranaceous, with a fmooth furface; and they are difpofed in the moft beautiful order, for the upper ones, tho' moving freely over the lower, always cover fome part of them.

If we duly confider this conftruction of the body, we cannot be at a lofs to account for the manner in which the Phyfalus, is able to fwell and bloat itfelf up with air, and afterwards burft, or as I think I may more properly exprefs myfelf, collapfe into its former fize and figure; to do all this, it need only firft dilate the upper portion of its fkin, that, on its floating to the furface, as it muft neceffarily do when its bulk is thus increafed, the air may get into the cavity fo formed, and then contract the fame part, fo as to make it expell the air contained therein; it then falls flat againft the lower part fo fuddenly, as to imitate the noife as well as appearance of a real burfting. Hence we may alfo fee why the Phyfalus, during this laft operation fhould appear quite tranfparent, as the fubtile air impelled at this time under the fkin, cannot but open an eafy paffage thro' it, for the rays of light.

As to the vifcera of this creature, there are many and remarkable fingularities in them; but as I have yet beftowed little notice and few defigns on them, I cannot fay much of them at prefent. I only remember to have obferved that the parts about the mouth of the Phyfalus are moveable in the manner of thofe of the Snails, and are of a pyramidical form, and of a very wonderful contrivance; its heart alfo, and blood-veffels fhew themfelves in a very beautiful manner. In the middle of the body I found a part which feemed in its upper portion to anfwer the purpofe of a ftomach, and towards the tail that of inteftines. This veffel was divided into a great many ramifications, which were united, as it were, by mutual anaftomis's or inofculations, Tab. X. Fig. XVI. *c*, and were full of, and turgid with, excrements of a kind of earthy clayey colour, divided into little lumps.

As I never faw this creature alive, and even dead, only after it had been toffed about by the waves from one part of the fhore to another, I can propofe but few things of it as certain. I don't know whether it is to be accounted venomous, as Rondolet feems to entertain that opinion; neither can I take upon me to determine among what fpecies of animals it is to be claffed, tho' it feems to deferve a place amongft Echini, or Sea-Urchins. Rondolet reckons it among his Sea-Caterpillars; but I cannot difcover in it the leaft refemblance to thefe creatures. I fhall therefore, for the prefent, conclude this hiftory; but fhall endeavour to complete it, if an opportunity offers, at fome other time, when I may have leifure fufficient to beftow on fo interefting a fubject.

The end of the Hiftory of the Phyfalus.

An epiftolary differtation on the Felix Mas, or Male Fern of Dodoneus.

SIR,

YOU do me no more than juftice in attributing to me the firft difcovery of Fern; for which reafon I fhall now lay before you a very curious obfervation on this fubject, with drawings to illuftrate it. Were this a proper feafon to obtain one of thefe vegetables frefh and in good order, I fhould endeavour to fend you more particulars worthy of your attention; what I now offer being only the refult of a furvey taken of it in a dead and dry condition. I may fay, however, that it is now feveral years fince, on examining by chance the tubercles growing on the under-furface of the Fern-leaves, I difcovered in them certain little capfules, containing the true feed of this plant; tho' many celebrated writers had denied that it had any, whilft others, who believed the contrary, knew not how to convince the former of their miftake.

The Male Fern of Dodoneus is a plant too common and well known to require a defcription; fo that I fhall only give a drawing of it, Tab. LIII. Fig. I. *a a*, and the tubercles *b b*, which grow upon its leaves. Thefe tubercles, which the ignorance and negligence of writers had confidered as little collections of fine duft and dirt, when carefully viewed, exhibit the moft wonderful conftruction that the mind of man can imagine, and fo eminently difplay the contrivance, order,

order, providence, and wiſdom of the Great Author of all things, that perhaps a more ſtriking ſpecimen of theſe His adorable perfections is not to be found in any other part of the viſible creation.

Every tubercle conſiſts of certain ſmall leaves, which contain the pods, or true capſules of the ſeeds. At preſent I cannot tell the number of theſe little leaves, as I have none but dry plants by me, in which theſe appear in a diſorderly manner, and curled up like the Fungus we call Jews Ears.

The pods juſt ſpoken of lie within theſe little leaves in the ſame manner as the flowers of the Moly are diſpoſed within the globule ſcabbard, or cup which ſurrounds them, before it burſts and expands itſelf into leaves: at this period, theſe flowers reſemble ſo many round balls placed upon ſtalks; and the ſame conſtruction obtains in the pods of the Fern-ſeeds, which ſtand within the leaves ſurrounding them, each upon its own ſtalk or pedicle, and look in a manner like ſo many ſlender ſtems with large heads.

To give you, Sir, a ſtill better idea of this ſubject, I lay before you a drawing of theſe pods, with their foot-ſtalks, and I ſhall add a deſcription of them. Theſe ſtalks are ſometimes ſingle, Tab. LIII. Fig. II. *c c c*, and ſometimes double, dividing at a little diſtance from their roots *d*; in this caſe each branch carries its own ſeparate pod.

That end of the ſtalk next the pod, is of the moſt ſingular conſtruction that can well be imagined; it there reſembles in that part a furrowed or fluted cord *e e e*, which beautifully encompaſſes the pod in form of a crown, and ſurrounds it like an herbaceous zone; ſo that the two hemiſpheres of the pod ſwell beyond it on each ſide *f f*. The colour of this little cord, when the ſeed is ripe, is of a very pale brown, within the flutings; but the oblong intermediate protuberances are of a ſomewhat deeper brown. There are twelve of theſe protuberances, beſides ſome certain ones, which ſometimes ſpread over the ſurface of the pod itſelf.

The pod is membranaceous, and very delicate *g*; and it is conſtantly of the ſame colour with the ſeed it encloſes. Near the middle of it there is a kind of furrow or ſlit, which divides it into two portions. When the ſeed is full ripe, the pod which till then, was of a tranſparent whiteneſs, turns to a blackiſh brown.

As ſoon therefore as the ſeeds have acquired their perfect degree of maturity, and the little cord is contracted, by drying into the form of an extended line, by a kind of elaſtic power, it endeavours to form a ſtraight line, Tab. LIII. Fig. II. *h h*, and by that means, on a ſudden, very exactly divides the pod into its original, two hemiſpheres *i i i*, ſo as to ſcatter with ſome violence the encloſed ſeeds into the air. And when this has juſt happened, we may ſee the cavity of the pod divided by little partitions into a number of cells where all the ſeeds have been ſeparately formed.

All theſe particulars, Sir, may be very clearly and diſtinctly ſeen, by examining the ſeeds with a microſcope towards the end of ſummer. In doing this myſelf, I found it neceſſary to bring my head very near them, and I very often had the pleaſure of ſeeing a great number of the pods burſt, and ſcatter their ſeed by the force of the ſurrounding cord, at that time endeavouring to extend itſelf, in conſequence of the contraction or criſpation cauſed in it by the breath from my mouth, and the heat of my body.

As to the ſize of theſe pods, it is a hard matter to give a drawing of them after nature, on account of their extreme minuteneſs, which renders them almoſt imperceptible to the naked eye. Nay, a dot of ſo ſmall extent can ſcarce be made on paper with the fineſt pencil: but the ſeeds themſelves are of ſo amazing a minuteneſs, eſpecially when dry, that the ſharpeſt eyes cannot, unaſſiſted, diſcern them at all. I reckoned above forty-one of theſe ſeeds in one pod, though it had before ſhed a great number.

Who then, Sir, can pretend to ſhew in this ſeed, as may be done in ſome others, the germen or bud, the rind or bark, and leaves of the future plant? No one certainly; here therefore, the Great Creator gives us a complete ſpecimen of His excellent work; to exhibit which properly, is far beyond the reach of the greateſt genius for deſcription and drawing; and it is ſcarce a wonder, that the greateſt naturaliſts were ſo far miſtaken, as to affirm, this plant was quite deſtitute of ſeeds.

I cannot at this time give you a drawing to repreſent the true figure of this ſeed, as what I have by me are dried up, and ſome of them appear larger than others; however, I cannot help letting you have one made as well as I could, from ſuch a dried ſeed in this cloudy winter ſeaſon. Its ſurface is ſomewhat irregular and angular, with certain tubercles on the upper part; which, under the microſcope, appear of a net work form, Tab. LIII. Fig. III. *k*; but it is very difficult to examine theſe ſeeds when expoſed to the air, or turned to the light, becauſe they are of a deep brown colour, as I diſcovered, by endeavouring to view them in the open air, fixed to a hair of my head, which, in compariſon with theſe ſeeds, appeared like the maſt of a firſt rate ſhip.

Neither can I at preſent determine what the number of the pods may be, though I believe every tubercle contains more than ſixty, from whence it would follow, that every tubercle contained at leaſt 2460 ſeeds. The pods, when opened in the middle, plainly ſhew the little ſeeds diſtinctly ſtowed up in them, Fig. II. *l*; and as theſe grains have then acquired the utmoſt degree of maturity, and conſequently lie looſe, they may be eaſily ſhook out of their cells: but this is a ſight we muſt expect to obtain rather by chance, than certainly procure by diſſection; it ſo ſeldom happens, that any attempt to open a pod regularly is attended with ſucceſs. I can at all times ſhew the ſeeds and cords, and every thing beſides, which I have here deſcribed, as I did ſome time ago to Mynheer Arnold Syen,

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professor of botany, and Doctor Justus Schrader of Amsterdam, who both took great pleasure in contemplating these wonders of God in the vegetable kingdom. It is my real opinion, that the Fungi or Mushrooms, Corals, and other natural productions of that kind, have also their seed like the Fern, as I some time ago endeavoured to demonstrate in the Coral in particular, in two letters wrote to Monsieur Boccone upon that subject.

I cannot, Sir, find words to inform you with what wonderful order, and in how regular a manner, these pods burst under the microscope; with what force they then scatter their seeds; or with what a surprising motion the cords extend themselves; and with what incomprehensible wisdom and contrivance, the supreme Architect has so disposed every thing, that each part or portion of the bursted pod, should remain fixed to its cord at a particular place. But I hope the drawings I send, may be found sufficient to give you some notion of all these things.

I have found the same construction to obtain in the pods, seeds, and cords, of several different species of Ferns.: and I make no doubt, but it may be found in the Spleenwort, Hartstongue, Hermonites, and other plants of that kind.

Hence you may conceive, with what rapidity these seeds may be wafted about by the wind, so as to account for these plants being found on the tops of the highest trees, and on walls, wherever they can find mould enough to take root in.

The great obscurity of the human understanding, is clearly proved by this observation; for was it not very dark indeed, how could it, during so many ages, deny that this plant had either seed or flowers? insomuch that it was one of the first errors taught young people in books, as well as heard in conversation. We ought therefore to thank the sun of divine grace, and true fountain of all useful knowledge, that we are at last so happy as to attain more just notions of this matter. Should not this mistake teach us modesty in our opinions and our judgment upon many other occasions, seeing, upon this, the most penetrating geniuses have all gone astray? If we are so liable to mistakes in regard to things that lie open to our inspection, what are we to say of our opinions of things which are invisible? How many idle notions are formed on such subjects? how many senseless conceits, with which, however, we sometimes so far suffer ourselves to be deluded, that we make nothing of injuring both in character, and person those who happen to be of a contrary opinion? It is therefore absolutely necessary we should always distrust ourselves, and act with the greatest circumspection. In our present wretched condition, we are surrounded with ignorance on every side, and have no other true knowledge than that of our own weakness and imperfections. Of ourselves we can do nothing; all we have, we receive from the gracious hands of the Supreme Being, the munificent rewarder of good actions, of whose divine favour, I wish you an uninterrupted enjoyment.

A

Short EXPLANATION of the TABLES,

Which are more fully illustrated in the

BOOK of NATURE,

O R,

HISTORY of INSECTS.

By J. SWAMMERDAM, M. D.

TAB. I.

Explains the changes of the first order or class, which are represented to the eye, by the assistance of figures; for which purpose the Louse is exhibited as an example.

N. B. The numeral letters distinctly shew, after what manner the several changes succeed each other; some of the figures are represented as they are magnified by the microscope; the reader must observe in general, that the same method is also observed in the examples which belong to the second, third, and fourth orders or classes of the changes of insects.

No. I. SHEWS the nit or small egg of a Louse, delineated in its natural bigness, in which the Louse is contained; being yet clothed in its first skin or coat. The same may be seen *fig.* 1. as it is magnified by the microscope.

No. II. Is the empty shell of the egg, or the coat or skin of the nit, cast off by the Louse; after it has crept out of it.

No. III. Shews the Louse just excluded from its egg, where it plainly appears, how the creature has crept out of the membrane wherewith it was surrounded, in a perfect state; and is not obliged to undergo any further change, tho' afterwards it increases in bigness, and often changes its skin. Therefore we have named the Louse in this state, an oviform-nymph-animal: because it issues from its coat or skin, perfect in all its limbs.

No. IV. Is represented the same Louse somewhat bigger, and invested as it were in its third or fourth skin; which also soon after is to be cast off.

No. V. The Louse, having now attained to the full period of its increase, in which state we called it a nymph-animal; from its being then in its last skin that it sheds, and indeed we meet with some insects in the first class, which are also somewhat changed about the time that they cast their last skin, which plainly appears, among other instances, in the Longipede, or long-legged Spider, the legs of which increase in length when it is casting its last skin. After that is cast, the insects which belong to this first order grow no more, neither are they changed in any respect; as may be more plainly understood from the figures of the following examples of the four orders, under number V. and VI.

No. VI. The Louse, having attained its perfect state, and being fully grown, so that it is now capable of generation; is represented *fig.* III. as magnified by the Microscope.

F I G. I.

The egg, or nit of the Louse, as magnified by the Microscope.

a The oviform border or margin, with which the head of the nit is surrounded, within which are visible certain little cups or uvulæ, of no regular or determinate figure. These cups appear a little bent, and then again swell out in the middle, as it were into a whitish top. It is observable that these cups do not wholly fill the internal parts of the border or margin with which the head is surrounded.

b b Are two tender swellings or extuberances, wherein are placed the eyes of the Louse; whilst its limbs yet remain moist and soft.

These eyes, by imperceptible degrees, grow browner, and appear through the ſkin, and at laſt become entirely black.

c Is a certain white tranſparent part, in the middle of the nit, which we have often ſeen beating regularly in the ſame manner as the heart. This little part is repreſented in *fig.* VI. by letter *b*, and called by us the pancreas, becauſe it moves up and down with the ſtomach.

F I G. II.

The ſhell of the egg, or the empty nit, and the firſt ſkin which the Louſe caſts.

a The border or margin of the head burſt open, with its little cups or uvulæ, and turned back by the Louſe's creeping out at the upper extremity.

b The other part of the empty and caſt ſkin of the nit, from which the border of the head is ſeparated, by which means it has the appearance of a tankard without its cover.

F I G. III.

Shews the Louſe placed on its belly, and magnified by the microſcope.

There appears a ſhining ſkin on its head, with ſome little holes and diviſions. Upon its breaſt or back there is an elegant delineation of a ſhield, which is as it were painted in the middle; and this ſhining ſkin is ornamented with little holes. To the breaſt are fixed the legs, which are full of little ſwellings or extuberances, like thoſe on the ſhagreen ſkin; but they become by degrees imperceptible at the extremity of the legs. By the aſſiſtance of the microſcope it has been diſcovered, that at the margin of the abdomen, the ſkin there appears alſo painted and rough, with little grains like ſhagreen as before deſcribed; but by the help of the beſt microſcope, I have at laſt found that the ſkin is really formed of irregular chequered work, globules, and ſuch like appearances.

N. B. In *fig.* IV, next to be explained, will be pointed out by letters all the remaining parts of the Louſe, one after another.

F I G. IV.

The external and internal tranſparent parts and limbs which are ſeen in the Louſe, as lying on its belly.

a The Aculeus or ſucker.

b b The antennæ or little horns. *c c* The eyes.

d d The ſix legs. *e e e e* The claws.

f The cloven tail, in which the anus is ſeen.

g g The white tranſparent veſſels in the belly and breaſt, which are properly the ramifications of the trachea.

1 2 3 4 *&c.* The ſeven orifices of the pulmonary pipes, on one ſide of the body, which with ſeven others on the oppoſite ſide make together XIV.

h h h The large branches of the aſpera arteria, in their firſt beginning where they open by ſpreading branches into the extremities of the belly, and afterwards communicate together by an anaſtomoſis, or inoſculation.

F I G. V.

The Louſe, lying on its back, delineated according to its natural ſize.

F I G. VI.

The Louſe delineated with the aſſiſtance of the microſcope, in which thoſe parts which could not be ſhewn in fig. IV, *are here repreſented.*

a A brown tranſparent part of the abdomen, which is obſerved to be in continual motion, with its double tranſparent appendages, which are ſtretched far into the breaſt. This brown part with its appendages, is properly the ſtomach; in the middle of them is placed the ſpinal marrow.

b A white ſpot in the middle of the belly, tranſparent, which I imagine to be the pancreas. In a live Louſe it appears to be united with the ſtomach, and, together with it, is moved up and down.

Further, in this Louſe, the articulations of the legs with the breaſt may be plainly ſeen, alſo the bright tranſparent pulmonary pipes, together with the black coloured contents of the ſtomach. At the extremity of the abdomen appear the double claws, like creſcents, which cover the vulva.

F I G. VII.

The branch of the aſpera arteria of the Louſe, conſiderably magnified, yet repreſented in its natural form.

a The rings of the trachea, by which it is always kept open.

b The ſerpentinewindings of thoſe rings.

c The part where thoſe windings appear to be interrupted.

d The part where the rings are largeſt.

e The part where the rings become ſmall again, when the aſpera arteria ſhoots out into another branch.

f A ſmall membrane in the middle of the rings, which properly contains the air.

F I G. VIII.

The ſeven orifices or reſpiratory points of one ſide, ſeparately delineated.

1 2 3 4 5 6 7 Theſe figures ſhew the natural ſituation of the reſpiratory points or orifices of

of the aſpera arteria, in one ſide of the human louſe.

a a The reſpiratory points in the belly, which appear with little protuberances like ſmall nipples; beyond the margin of the belly.

b The reſpiratory point in the breaſt.

TAB. II.

FIG. I.

The blood of the Louſe.

a a A ſmall glaſs tube, in which the blood of the louſe aſcends.

b The globules of the blood as they appear through the microſcope.

FIG. II.

The muſcles of the Louſe.

a A broad muſcle. *b* Another narrower.

c A double-bodied muſcle.

FIG. III. IV. and V.

The ſheath or caſe of the aculeus, or ſucker, the aculeus, the throat, the ſtomach, the pancreas, and inteſtines.

a The caſe of the aculeus ſwelled out.

b The aculeus or ſucker.

c The caſe of the aculeus delineated a little larger, and the whole of it repreſented.

d Certain claws which are placed at the end of the caſe of the Aculeus.

e The Aculeus a little bent.

f The gullet beyond the jaws.

g The ſame a little dilated.

h The ſame part where it becomes narrower again, and is joined to the ſtomach.

i i i The ſtomach, which appears to be compoſed of certain globules.

k k The two hidden appendages of the ſtomach.

l l l l The pulmonary pipes of the ſtomach.

m The ſituation of the pancreas.

1 2 3 4 5 Five different delineations of the pancreas.

n The Pylorus. *o o* The ſmall gut.

p p p p The four ſmall guts.

q The inteſtine colon.

r r The dilatation or extenſion of the inteſtines, or Cloaca; where the excrements acquire their figure.

s The ſtraight gut. *t* The anus.

v The part where the blood firſt paſſes through the aculeus into the mouth.

x A remarkable extenſion, occaſioned by the blood's extending the jaws; there it becomes viſible, beyond which the gullet is afterwards ſeen, which conveys the blood into the ſtomach; as has been already ſhewn at letter *f*.

FIG. VI.

The various motions which the ſtomach makes.

1 The ſtomach dilated.

2 The manner in which the ſtomach contracts itſelf.

3 The ſame contractions changed.

FIG. VII.

The ſpinal marrow.

a a a Three knotty dilatations, or ſwellings of the ſpinal marrow.

b b b Six nerves which ariſe from the marrow, and extend to the muſcles of the legs.

c c The nerves which ſpring from the hinder part of the marrow, and are diſtributed through the reſt of the viſcera.

d d The pulmonary pipes in the membrane of the marrow.

e The beginning of the marrow iſſuing from the brain. *f f* The brain.

g g The Dura Mater, with its pulmonary pipes. *h h* The optic nerves. *i i* The eyes.

FIG. VIII.

The ovary of the human Louſe.

a a The vulva, or outward aperture of the ovary, opening into the lower part of the abdomen, cloſed with double plain claws; under which are ſome hairs.

b b b b The five double extremities of the pipes which form the oviduct of the ovary, explained in the figure of one ſide, and are alſo ſhewn in the figure on the other ſide; as they are naturally joined together in one point in the body.

c One of the ten oviducts of the ovary.

d A perfect egg placed in it.

e The rudiments of four eggs.

f f The diviſion of the ovary into common double pipes.

g g The five oviducts of one ſide, nearly repreſented in their natural ſituation.

h The uterus.

i The egg or nit almoſt at its perfection, remaining in the uterus.

k k The ſacculus, or bag which contains a glutinous matter.

l The neck of the uterus.

m The manner by which the eggs are cloſely embraced in the oviduct.

n Certain pulmonary pipes which are ſeen in the oviduct.

FIG. IX. and X.

The ſtructure of the external ſkin, with its various appearances under the microſcope.

a Globular particles viſible in the ſkin.

b b Long channels or pipes.

c Another kind of globular particles is feen among the channels or pipes where the fkin is membranaceous.
d Irregular fquares in the margin of the fkin.
e Circular grooves. *f* Globules.
g Globules and grooves.
h h The fkin marked with points or dots.

The end of the explanation of the figures of the Loufe.

Obfervations on Scorpions, reprefented in Figures.

TAB. III.

FIG. I.

The common Scorpion, and the particular parts of it.

a The head jointed to the breaft like as in a lobfter, is confpicuous in the fore-part, in which are two fmall forceps or pincers, and above are feen four eyes; in the middle of the breaft there are alfo two eyes, there being fix in all: which may be plainly known to be the number of the eyes.
b b Its eight hairy legs, each divided into fix joints.
c c Two crooked arms with pincers, each compofed but of four joints, if you except that by which each arm is joined to the breaft. Thefe forceps or pincers are fometimes found broken.
d The feven divifions or rings of the belly.
e The briftly part, compofed of fix joints.
f The aculeus or fting.

FIG. II.

Another kind of Scorpion.

a a The crooked arms with their forceps, which differ very much from thofe reprefented at letters *c c*. There are in this Scorpion eight diftinct eyes, in other refpects it agrees with the former.

FIG. III.

A large kind of Scorpion brought from the Eaft-Indies, in which the parts that were defcribed in the two former are more clearly feen, particularly the following.

a The two forceps or pincers placed foremoft under the head and breaft.
b Above which there are, on each fide, fix eyes, fome much larger than others: befides thefe there are, in the middle, as it were above the breaft, another pair of eyes. There is alfo a remarkable difference in the tail; but I am doubtful whether it was fo naturally.

FIG. IV.

A fmaller kind of water Scorpion, which belongs to the fecond clafs or order of changes, reprefented in its natural fize.

a The crooked probofcis.
b b The upper pair of wings.
c c The lower pair of wings.
d d d d The four legs, with two claws at the end of each of them.
e e The arms. *f* The double tail.
g One of its nits or eggs reprefented in its natural fize.

FIG. V.

The water animalcule in its egg, delineated as it appeared under the microfcope, which in Fig. IV. letter g, was reprefented in its nit of its natural fize.

a The head. *b* The eyes. *c c* The legs.
d d The animalcule, with its legs, laid on its back.

FIG. VI.

The parts of generation of the male water fcorpion.

a The nervous body of the penis cut off.
b The vas differens, as it is elegantly formed by nature.
c Another vas deferens, unfolded.
d The true vafa deferentia.
e e The tefticles, confifting each of five fmall glands.
f f The veffels of the tefticles united with the fmall glands of the tefticles.
g One of thefe veffels, unfolded.
h h The fmall feminal veffels.

FIG. VII.

A particular part of one of the oviducts, with its eggs, cut out of the ovary of a female water Scorpion, reprefented as magnified.

a a A particular part of one of the oviducts.
b The briftly appendages of the firft and loweft egg.
c The fame fhewn in the fecond egg.
d The like appearance about the third egg.

FIG. VIII.

The egg feperately reprefented, more confiderably magnified.

a The lower fmooth and round part of the egg.
b The part where the feven briftly appendages of the egg begin to grow of a red colour.
c Where they change to a white colour.

FIG. IX.

The largeft kind of water Scorpion.

a Its long and flender body.

b b The

b b The two ſharp ſmall points to which the two crooked claws of the arms are united.
c c The ſlender legs ſet with rough ſmall hairs.
d The membranous ornaments of the upper wings.

TAB. IV.

This table exhibits the covered or common Snail.

FIG. I.

The Snail with all its parts entire, without its ſhell.

a a The two upper antennæ or horns, with a certain black ſpot; which is the eye.
b b The two lower horns; without eyes.
c The outermoſt lips and the mouth.
d The aperture, through which the parts of generation iſſue; which is very wonderful.
e The border or lip of the ſnail.
f The opening through which the excrements are excluded.
g The aperture through which the Snail breathes.
h h The extreme fringes of the Snail, which ſerve it inſtead of a foot.
k The ſoft part of the body of the Snail, on which appear the ſame windings as in the ſhell, in which the liver is placed in the largeſt part.
l The tranſparent heart; ſurrounded with dots.
n The Sacculus or alkaline bag ſwelling under the ſkin.
t Tranſparent particles formed like a chain.

FIG. II.

The hard ſkin or ſhell of the Snail.

i The ſhell or habitation of the Snail in which it hides itſelf.
s The inciſions or diviſions on the ſurface of the ſhell.

FIG. III.

The Operculum or Cover.

m The operculum of the ſhell of the ſnail, which ſhuts up the ſhell in the winter, but is again opened in the ſummer.

FIG. IV.

A boiled Snail repreſented of a leſs ſize.

o The alkaline bag ſwelled quite out.
p The extreme convolutions or windings of the liver.
q The border of the Snail contracted.
r The teeth as they appear under the ſkin which is drawn back, and the internal lips.

FIG. V.

A part of the firſt pair of horns, repreſented as magnified.

a The eye in the middle of the extreme point of the horn, placed a little on one ſide.
b The optic nerve.
c The extreme point of the muſcle of the eye.
d An interſection of the eye in the middle, between the muſcle and the nerve; where the eye is firſt drawn in.
e e e Small glandulous grains in the outermoſt ſkin of the horn.
f The inner cavity of the horn, which is ſaid to be poſſeſſed of a muſcle and nerve.

FIG. VI.

The brain, nerves, and muſcles.

1 2 3 4 The four horns inverted.
a a The muſcles of the larger horns.
b b The two ſmall muſcles of the leſſer horns.
c c The four horns of the lips, from which the two little ones ſpring.
d The brain.
e The ſkin drawn off the head, by which the hinder brain is moved when the Snail rolls the ſkin out again.
f The part in which the teeth are fixed, deſcribed by dots, which are of a ſubſtance between horn and bone, and formed like a pear.
g The parts of the jaws, mouth, palate and tongue, which are all moveable, and drawn within the body.
h A particular part of the ſtomach and gullet.
i i The ſalival veſſels.
k k The optic nerves of the upper horns.
l l The membranes which extend, and are fixed to the optic nerves.
m The part of the muſcle in which the optic nerve is inſerted.
n The ſpiral windings of the optic nerve.
o The muſcle, which involves thoſe nerves, open.
p The extreme ſwelling of the optic nerve.
q The eye placed in the extremity of the optic nerve.
r The nerve of the lower horn of one ſide,
s The origin of the nerves of the lower horns.
t Two nerves which are diſpatched to the larger horns.
v The two nerves of the mouth, jaws, and palate.
x Part of a muſcle which draws the nerves of the mouth together with the jaws, tongue, palate, and brain, inward, at once; in a very wonderful manner.

FIG. VII.

The eye, with its particular parts, repreſented as magnified.

a The external figure of the eye.
b b b A muſcle which embraces the optic nerve, unfolded, like a gray-coloured membrane.
c The nerve itſelf, in which the eye is fixed.
d A part of the inverted horn.
e The inverted cavity of the horn.
f The part where the muſcle is faſtened in the nerve.

FIG. VIII.

The three humours of the eye.

a Two needles with which the tunica uvea, lying under the microfcope, is pricked.
b The aqueous humour iffuing from the wounded eye.
c The vitreous humour flowing out in the fame manner.
d The cryftalline humour iffuing like the others.

TAB. V.

FIG. I.

The open parts of the mouth and jaws.

a The external fkin in the form of teeth.
b The tooth, placed high in the mouth, cut, with the fkin, from one fide, expofed to view.
c The tooth fpread out into horny bony points, like needles.
d The falival veffels, with their openings.
e The inner lips, behind which the mouth is folded together.
f A cartilage which covers the tongue, when the Snail fwallows its food, under which the tongue may be fheltered in the cavity. All thefe parts are fhewn, unfeperated, Fig. IV. Letter *r*.

FIG. II.

The Tooth.

a The whole horny bony coalition of the teeth.
b The eight prominent teeth of it.
c The crooked crefcent form of the teeth.

FIG. III.

The tongue, and certain mufcles.

a The tongue, taken out of the mouth.
b The root of the tongue, with its fituation; the tongue itfelf, as it appears, where all the parts of the jaws and mouth are reclined to the other fide.
c The two horny bony teeth in the acute extremity of the tongue.
d The three mufcles, which move the parts of the gullet and mouth forward.

FIG. IV.

The heart, its auricle, and the blood and falival veffels.

a The reins, which are vifible in the internal membrane of the border of the Snail, as they are derived from the trunk of the vena cava.
b The aperture of the border.
c The heart with its two valves, and fibrous columns.
d The auricle of the heart.
e The alkaline bag, in its proper place, near the heart.
f The ftraight gut, near which runs the pipe of the alkaline bag.
g The fpreading branch of the great artery.
h Certain large branches and fprigs of the great artery.
i i i The circumvolution and fhape of the body reprefented by dots; that the fituation of thefe parts may be the more exactly demonftrated. Here may be further obferved:
n The oblong grooves or channels of the ftomach.
o o The falival veffels.
p p The trunk from which the falival veffels fpring.
q A fmall veffel which runs over that trunk.
r All the parts of the mouth.

FIG. V.

The alkaline bag.

k That part of the alkaline bag which is connected with the Pericardium.
l The angle where the alkaline bag is connected with the inteftine and liver.
m Another part of the alkaline bag adjacent to its own pipe, and of a waterifh colour.
N. B. We have joined in one Table the Fig. IV. and V. the explanations of which are here feperated, becaufe though we found, in the author's manufcript, the explanation of Fig. V. by itfelf, yet we could not meet with the figure itfelf apart in the Table; but that does not fignify, as it may be underftood by the fourth figure.

FIG. VI.

The ftomach, inteftines, and liver.

a The extreme winding of the liver.
b b b The lobes of the liver, where it appears at once, after what manner the inteftines are wound about; a certain part of it, with the ftomach, is reprefented out of its place.
c The ftomach. *d* The Pylorus.
e The ftraight gut.
f The paffage of the inteftine into the border.
g The part where the biliary ducts empty themfelves into the inteftine.

FIG. VII.

The fame parts reprefented, as reviewed from the other fide.

a The liver. *b* The inteftines.
c The ftraight gut. *d* The ftomach

FIG. VIII.

The biliary ducts.

a The naked biliary ducts, with a fmall part of the liver.

b The

b The ſtomach. *c* The ſmall guts.
d The ſtraight gut.

FIG. IX.

The veſſels of the liver.

a Several veſſels of the liver ſeparately repreſented.

FIG. X.

The genital parts of the male and female,

a The penis.
b b The length of the penis, and the extreme point of it.
c c c The uterus. *d d* The ovary.
e The teſticles, which are ſmall filaments that ſpring from two trunks.
f The hidden appendage of the uterus.
g The common duct between the penis and uterus.
h h The oblong vas deferentia.
i Its ſmall tube, which opens itſelf into the uterus.
k The pear-ſhaped little ball, in which the purple Snail keeps its purple liquid.
l A little part twiſted like a chain.
m Its duct, or little pipe.
n n n The ligament of the uterus.
o The muſcle which leads the penis outward.
p The muſcle which draws the penis inward.
q The nerve of the penis,
r The mouth of the vulva.
s The broad muſcle of the uterus.
t The ſlender muſcle of the uterus.
v The nerve of the uterus.
z The extremity of the chain-like little part.

FIG. XI.

The teſticles.

x The little tubes of the teſticles, conſiſting of filaments, of which ſixty-ſix are reckoned.

FIG. XII and XIII

The blind appendage of the uterus opened, with the ſaline bony contents.

y The blind appendage of the uterus divided in the middle, between which the ſaline bony part, which readily ferments in aqua fortis, is ſeen.
a The root of the ſaline bony part, by which it is joined to the muſcular and nervous pear-ſhaped globule.
b The fine ſmooth part of it, which is all hollow; and by degrees becomes more ſlender and acute.
c The pear-ſhaped globule, to which the ſaline bony part is fixed.
N. B. Here again we have marked a ſingle figure with a double number, becauſe we could only find, in the Tables, the XIIth figure, although in the body of the work, and in the ſhort explanations of the tables, we find the XIIIth quoted: but this is of ſmall importance, as the figure which we have given contains all the particulars that we want.

FIG. XIV.

A particular ſmall ſtony, or ſaline bony part, as ſeen by the microſcope.

d d d d The four margins, or ſurrounding backs.
e The cavity ſtretched out in the middle of the boney part.

FIG. XV.

The chain-like part.

a The extremity of the chain-like part unfolded, in order to ſhew its conſtruction.

FIG. XVI.

The uterus.

r Exhibits the cavities of the uterus blown up, in order to ſhew how the diviſions of it are formed.

FIG. XVII.

a Here are ſeen in the neck of the amorous Snail, the external opening of the vulva, or genital parts, which with the part under the penis, and the appendage of the uterus, together with all the ſpermatic veſſels have been already repreſented in *fig.* X. let. *r.*

FIG. XVIII.

The penis and uterus themſelves turned out and erected.

b The penis and uterus turned out and erected, and ſtretched out beyond the neck.
i i The two upper horns.
k One of the lower horns, which is then a little removed from its place.

FIG. XIX.

The penis, and internal orifice of the womb.

c The penis only, not wholly, turned out of its cavity, and erected.
d The internal orifice of the womb alſo a little turned out, and extended out of the neck.
l The lower horn removed from its place, toward the horn of the other ſide.

FIG. XX.

Of their copulation.

e The penis of one of the Snails rolled out.
f The apperture of the uterus of the other Snail, admitting the penis of the former.

g h The

g The aperture of the uterus of the firft Snail, which in like manner admits the penis of the other Snail *h*.

TAB. VI.

The brain and nerves.

a All the parts of mouth, jaws and palate.
b The gullet cut off. *c* The brain.
dd The beginning of the fpinal marrow, divided into two ftrong nerves.
e The knot or fwelling formed by the nerves.
f The mufcle by which the knot, or fwelling of the fpinal marrow is inwardly moved.
g The two parts of the mufcles, which belong to the inward lips of the mouth, which are inferted by fome tendons in the knot or fwelling of the fpinal marrow, and which, together with the nerves, the mufcles draw within the body.
hh A pair of nerves which are feen in the mouth, jaws and palate.
ii A pair of optic nerves.
kk A pair of nerves which reach to the roots of the horns and to the fkin.
ll. The nerves of the lower horns which arife from the former pair.
mm Two tender nerves, which reach to the mufcles of the fkin and head, cut off.
nn A pair of nerves fituated under the parts of the mouth.
oo Other pairs of nerves which are difpatched to the mufcles of the neck.
p A nerve which reaches to the fpermatic veffels, to which alfo a fmall part of the penis adheres.
q The nerves which are diftributed thro' the membranes of the neck.
rr The nerves which are difpatched to the mufcles at the fides of the body.
s A nerve and mufcle which reach to the uterus.
t A nerve of the verge ftretched inward to the right fide.
v A like nerve on the left fide.
x The nerves fixed in the tendons of the two ftrong mufcles, which move the middle of the body. See *fig.* II. *nn* of this Table.
yyy The nerves which reach to the verge of the foot of the body.
z Some of thefe nerves cut off from the right fide are omitted, to avoid confufion.

FIG. II.

The mufcles of the Snail.

a The part of the ftony bone or fhell of the Snail, where the mufcles are inferted.
bb The infertion of the two ftrongeft mufcles of the Snail, by the affiftance of which it creeps and moves.
c The part where thefe mufcles ftretch the tail itfelf backward or inward, and which pafs under the pillar of the fhell.
d. The part where the mufcles of the verge are inferted.
e The mufcles which draw in all the parts of the mouth, jaws and palate.
f The acute extremity of the tongue.
g The bafis or root of the tongue.
hh The mufcles of the eyes.
ii The curled foldings of the nerves among thofe mufcles.
kk A part left of the firft pair of horns, ftill adhering to the mufcles.
ll A pair of mufcles which draw the lips and the knot or fwelling of the fpinal marrow inward.
mm The mufcles of the lower horns, which arife from the former pair.
nn Two ftrong mufcles which draw the middle of the body into the fhell.
o The part where they are inferted.
pp The internal furface of the fhell, in which its fpiral windings, cells, and circumvolutions are feen.
qqqqq The fringe or border, or foot of the Snail.
r The cavity of the pillar.

FIG. III.

The convolutions, or windings of the fhell.

a The outward opening of the fhell at which the Snail creeps out, and the winding which forms the firft cell or inward divifion.
b The fecond divifion. *c* The third.
d The fourth. *e* The fifth and laft.

FIG. IV.

The internal part of the fhell broke open.

1 2 3 4 5 Are feen the inward windings of the fhell, when all the partitions are broke open.

FIG. V.

The Pillar.

a The upper aperture and windings of the pillar.
b The lower aperture of the pillar, which may be feen more plainly in *fig.* II. *r.*

FIG. VI.

The Pillar.

c The aperture, the fpiral windings, and the conftruction of the pillar diftinctly reprefented.

FIG. VII.

Shews in what manner the greater or lefs divifions of the fhell may be formed, as it is broken off from the pillar and its partitions.

d A part of the fhell broken off, almoft to the end of its fpiral winding.
e f Two others, lefs broken

TAB. VII.

TAB. VII.

FIG. I.

The Turbo or Verticillum.

a The beginning of the windings of the Turbo.
b The end of thofe windings.

FIG. III.

The voluta, or the cylinder or pyramidal Snail,

a The opening or entrance of it.
b Where it becomes narrower.
c Another convolution or winding.
d The pillar and the other internal fpiral windings of it.

FIG. III.

The Concha Veneris.

a The entrance divided into little teeth.
b The windings round the pillar.

FIG. IV.

The pencil Snail.

a The outward entrance of it.
b Another of its winding divifions.
c The third. *d* The fourth. *e* The fifth.
f The fixth. *g* The feventh.

FIG. V.

The tubular Snail.

a The beginning like a plain tube or inteftine.
b. Its fpiral windings and convolutions.

FIG. VI.

The tubular Snail.

c c The cavities which the tubular Snail forms, when the partitions of it are gradually convolved together, and applied one to another. But if their cavities are joined to others, the cavity of the pillar is thereby formed. See *Tab.* VI. *Fig.* II. *r.*

FIG. VII.

A Snail like the Cornu Ammonis.

a The hollow perforated partition in the beginning of the Snail,
1 2 3 4 5 *&c.* The divifions of the Snail, which are formed by the various number of the partitions.

FIG. VIII.

The partitions, with the naked furrounding fhell,

b b Six partitions, from which the outward fhell is removed.
c The part where the little tubes of the partitions are mutually received.

FIG. IX.

A partition, with its little tube reprefented of a large fize.

d d d The extreme compafs of the partition.
e The aperture of the partition which leads to the little tube.
f The perforated handle, or little tube of the partition.

FIG. X.

Three partitions of different fizes, which mutually receive each other.

g The little tube of the firft partition, fixed into the little tube of the fecond partition.
h The little tube of the fecond partition, fixed in the tube of the third partition.
i i i i The partitions, with their little tubes gradually decreafing in fize.

FIG. XI.

The oval Turbo, with its windings turned contrary to thofe in other Snails.

a The entrance opening into the oppofite fide, and obliquely winding afcends towards the left.

TAB. VIII.

FIG. I.

The little Turbo.

a The fhell of this Snail, with its windings turned the contrary way.
b Part of the body of the Snail creeping out of the fhell.
c c Its two larger horns, in which the eyes are placed.

FIG. II.

The fhell of the Snail reprefented, and of an enlarged fize.

a The entrance extended to the oppofite fide.
b The aperture of the pillar.
c c c The ridges, or ribs of the furface.

FIG. III.

The fhell of the fmall Snail, found under the barks of the Willow.

a The fhell of the fmall Snail; a little flatted.

FIG. IV.

The fmall water oval Snail.

a The oval channelled fhell of the Snail.
b The hinder part of the fhell convolved into a double fpiral winding.

c The body of the Snail which creeps out from thence, marked with black points or ſpots.
d The two obtuſe horns, in which the eyes are are placed, alſo the upper, lower, and ſmaller horns.

F I G. V.

The garden Snail.

a The aperture of the genital parts, placed a little lower in the neck than in the common Snail.
b b The uterus.
c c The ligament of the uterus.
d The bag which holds the glutinous moiſture.
e The chain-like little part.
f The little legs in the ovary.
g The extreme ſpiral part of the liver.
h The purple little knot.
i The other ſmall tube of the purple little part.
k The connexion of the purple little knot with the uterus.
l The blind appendage of the uterus.
m The teſticles
n The alkaline little bone. *o o* The penis.
p The muſcle which draws the penis.
q The common duct between the penis and uterus.
r The acute end of the penis, curled into various windings.

F I G. VI.

Two garden Snails, in the act of coition.

a The penis of each wonderfully twiſted together.
b The penis of one of the Snails inſinuating itſelf into the
c Uterus of the other.
d The penis of the other Snail, in like manner, inſinuating itſelf into the
e Uterus of the former Snail.
f The aperture and diviſions of the verge, as ſeen in this Snail, at this time.
g At the ſame time nothing is ſeen of the verge in the other Snail.

F I G. VII.

The naked houſe Snail.

a The upper horns, which have eyes.
b b The lower horns, which are much ſmaller.
c c The velabrum, or eminence which is fixed to the body.
d The aperture in the neck, through which the genitals are extended.
e The aperture of the velabrum, by which the Snail breathes.
f The prominent part of the tail, like a cock's comb.

F I G. VIII.

The Snail ſtone.

a The hollow like Snail ſtone.
b The ſurface of it, interwoven as it were with veſſels.

F I G. IX.

The genital parts of the houſe Snail.

a The three apertures of the genitals, in the neck, which unite in one paſſage on the outſide.
b b The penis. *c c c c* The uterus.
d The purple bag
e A ſmall filament, which reaches from the penis to the ligament of the uterus.
f f f The ligament of the uterus.
g g The ſmall eggs ſticking in the womb.
h h A bag, containing a glutinous matter.
i i A chain-like little part.
k The ovary.

T A B. IX.

F I G. I.

The field or path-way Snail.

a Its larger horns.
b The aperture of the velabrum, or the eminence, by which it breathes, and diſcharges its excrements.
c c Glandulous triangular protuberances, which riſe obliquely from the body.
d d The gloſſy red verge which ſurrounds the body.

F I G. II.

The internal parts of the field or path-way Snail.

a The mouth and palate.
b b The larger horns drawn in.
c The ſkin of the head divided.
d The gullet. *e* The brain.
f The beginning of the ſtomach.
g g The ſalival veſſels.
h h The glandular corpuſcles, from which the ſalival veſſels ariſe.
i The ſtomach covered with veſſels.
k k The inteſtines. *l l l* The liver.
m The large gall-bag, which diſcharges itſelf into the inteſtines.
n The aperture of the genitals in the neck.
o The penis.
p The little tube which opens from the penis, into the uterus.
q The purple bag.
r The little tube of the purple bag, which is inſerted in the penis.
s The ſtrong and thick origin of the uterus.
t The ſlenderer part of the origin of the uterus.
u u u u The uterus itſelf.
x x x Whitiſh veſſels, which connect the uterus and its ligaments.
y y The glutinous bag.
z The chain-like little tube.
α The ſmall gut. *β* The ovary.
γ The heart in its place. *δδ* The alkaline bag.

F I G.

FIG. III.

The ovary of the field or path-way Snail.

a The ovary large and expanded, as it appeared ſome months after coition.
b b The little eggs, viſible in the ovary.
c The chain-like little part.

FIG. IV.

The common water Snail.

a Its turbinated ſhell.
b b The eyes placed at the bottom or root of the horns.
c c The horns, which terminate in ſharp points.
d The aperture of the verge.
e The aperture through which the penis comes out.
f The opening of the uterus.
g g The verge fitted to the internal ſurface round the ſhell.
h The tooth.
i i The body, by which the Snail creeps and ſwims.

FIG. V.

The internal parts of the wonderous viviparous Snail.

a The Snail taken out of the ſhell.
b The head. *c c* The horns.
d d The eyes. *e* The vulva. *f* The gills.
g The verge.
h The windings of the body.
i i i The part which ſerves as a foot.
k The cover of the ſhell, which is placed on the foot.

FIG. VI.

The internal parts.

a a The cover of the Snail preſſed cloſe againſt the fore parts of the body.
b The horns and mouth contracted.
c The Vulva.
d The fringe or margin, beautifully folded.
e The end of the ſtraight gut.
f The gills.
g The uterus, open; containing the living fetus.

FIG. VII.

The little Worm found alive in the wonderous viviparous Snail.

a The oblong figure of the Worm.
b The oblong tranſparent furrows or ridges which appear in the body of the Worm.

FIG. VIII.

Two ſmaller Worms, which iſſued out of one of the Worms in diſſecting.

a Its thick head. *b* The ſlender tail.

FIG. IX.

A ſmall live Snail, found in the uterus of the wonderful viviparous Snail.

a The ſize of that ſmall Snail, equal to that of a common pea.

FIG. X.

The ſhell of that ſmall Snail, as magnified.

b The beautiful conſtruction of the ſhell.
c c c c c c c Seven rows of briſtly hairs, with which it is ſurrounded.

FIG. XI.

Perfect eggs found in the uterus of a viviparous Snail.

a a a The little navel-ſtring by which they are fixed to the uterus.
b b The double navel-ſtring of one of the eggs.
c c c A ſmall Snail, ſticking in an egg.
d d The ſame taken out of its egg.
e A Snail, ſticking in its egg, which fell to the bottom, when the ſhell was ſuſpended by its ſtring.

FIG. XII.

A ſmall Snail taken out of its egg, and magninified by the microſcope.

a a Its eyes, black like pitch.
b The horns. *c* The mouth.
d The reſt of the body.
e The operculum, or cover annexed to the tail.
f The ſhell of the ſnail.

FIG. XIII.

The ſhell of the viviparous Snail, repreſented in its natural ſize, cleared of its foulneſs and perioſteum; in order to ſhew, the more diſtinctly, its form and conſtruction.

FIG. XIV.

The ſea Snail, called by the Hollanders Aliekruyk; they are found among muſcles.

a The Snail itſelf, with its little horns, eyes, and foot.
b The part where the ſhell of this Snail is of a globular form.
c Prominent hollows or channels on the ſurface of the ſhell.
1 2 3 4 5 The windings of the ſhell.

FIG. XV.

Another ſpecies of the Snail, called Aliekruyk, commonly ſold in Amſterdam.

d A kind of wreaths, which ſurround the ſhell, adorned with a colour like that of muſk, in the interſtices of which the ſhell appears green.

e Five

e Five oblong, crooked, hollow openings; eaten through by worms.

FIG. XVI.

One of those worms which eat through the shells of the Snails, represented of its natural size.

FIG. XVII.

The same Worm, represented as magnified.

a The head. *b* The tail.
c c Many small hairs on each side of the body.

FIG. XVIII.

The Snail, called Aliekruyk, represented as magnified.

a The head and mouth. *b b* The horns.
c c The eyes. *d d* The foot or verge.
e The cover of the Snail, of which only a small part is seen.
f The shell very large, with its wreaths worn out.

FIG. XIX.

The cover of the Snail, represented as magnified.

g The cover, whose convolutions are formed like the windings of the shell.

FIG. XX.

The tongue of the Snail, called Aliekruyk, of its natural size.

h The fore part of the tongue, situated in the mouth.
i The part of the tongue placed within the body, beautifully folded in serpentine windings.

TAB. X.

FIG. I.

The small water Turbo.

a The shell of the small water Turbo, which is formed very like the viviparous Snail.

FIG. II.

The umbilicated marble water Snail.

a The fore part, formed like an umbilicus, or navel.
b The oval broader part.

FIG. III.

The flattened water Snail.

a a The two lips. *b b* The verge or foot.
c c The black eyes. *d d* The horns.
e The long slender body.
f The air hole in the verge.
g The aperture of the genitals.
h h The shell of the Snail flat on the left aside.

FIG. IV.

The other side of the shell, of the same Snail, represented.

a The right side of the shell, which is concave, and, sinking in the middle, is rolled into itself.

FIG. V.

The small flattened Snail.

a A small margin, which surrounds the shell.

FIG. VI.

The fresh water Muscle, found in the rivers in Holland.

a a The lips or verge which surround the whole body.
b b The papillæ, or nipples of the muscle.
c c c c The four large gills.
d d d d The four small gills.
e The hard part of the body.
f The soft part of the body.

FIG. VII.

The inside of the shell of the Muscle represented.

a The part, in the acute extremity of the shell, where the muscle is fastened.
b The part in the thick or broad extremity of the shell where the muscle is fastened: where are visible four small holes.
c c c The part where the mouth of the muscle is fastened.
d The spiral winding of the shell.
e e The two eminences, by the help of which both valves are strongly joined together, as by ginglymus.

FIG. VIII.

The Physalus laid on its back, in order to exhibit the wrinkles on its belly.

a a a Twenty-eight of the greater, and some of the lesser external, parts, extant on each side of the body, and from which there spring black stiff bristles, of which there is but one side to be seen in this place.
i i i Some woolly hairs like down, of a gold colour, and placed under the parts, containing the lateral bristles. But I have here omitted these bristles, in order to render the hair itself more conspicuous.
l The opening of the mouth, above which appears a kind of beard, like that of bearded fishes.

FIG. IX.

One of the above eight and twenty greater external parts, seperated from the body, and exhibited by itself, with its black bristles.

b An Articulus, or joint, represented by itself, and shewing in what manner the bristles grow from under it.

FIG.

FIG. X.

The said bristles, represented in three orders, as they appear when plucked from the parts producing them.

c The ligament that connects the bristles, and afterwards appears about all the other bristles.
d Two of the largest and stiffest bristles with their ligament, which is placed almost in the middle of them.
e Six bristles with their ligaments some of which are more fine and delicate than others.
f Eight bristles with their ligament, differing in structure, length and stiffness.

FIG. XI.

One of the said bristles seen through a microscope.

g A flattish bristle ending in a point.

FIG. XII.

Another bristle viewed likewise through the microscope.

h A long round smooth bristle, somewhat more swollen on the forepart, but afterwards terminating in an obtuse point.

FIG. XIII.

Some hairs of a golden colour, with their roots.

k Some very fine hairs, like down, springing also from one centre or spot like the bristles.

FIG. XIV.

The sloping region of the back, covered with bristles and delicate hairs, and moreover of a somewhat convex form.

FIG. XV.

The back of the Physalus laid open.

a a a a a a The natural openings on each side of the body, thro' which the water flows to and from the gills.
b b b b The membranaceous gills which move freely one over another, like the larger scales in fish.

FIG. XVI.

The intestines of the Physalus rudely delineated.

a The structure of the intestines, which look as if they communicated with one another.

TAB. XI.

FIG. I.

The Cancellus, with its bony or shelly skin

a The shell, or true skin of the cancellus.
b The five spiral windings of the shell.
c Two eyes, below which are some bristly articulated hairs.
d d Two horns.
e The right arm, and its forceps, which is the largest.
f The left arm, which is the least.
g g The four foremost legs.

FIG. II.

The Cancellus, out of its skin or shell, lying on its back.

a a The eyes, between which are seen four bristly articulated hairs.
b b The horns. *c* The left and least arm.
d The right and largest arm.
e The two first pair of legs.
f f The third pair of legs, which has small forceps.
g g The fourth pair of legs, which are worthy of notice, because perforated by a double little tube of the genitals, to which it yields a passage.
h h Three articulated bristly hairs, to which the eggs are strongly fixed.
i The tendinous point of the muscles, or the part in which the tendons of the muscles meet, and where the Cancellus is fastened in his shell, that it can never go entirely out of it.
k The tail, with its particular part.

FIG. III. IV. and V.

The tail, the straight and closed guts, and appendages of the Cancellus, represented a little larger than they naturally are.

a The tail, consisting of two testaceous articulations.
b The verge of the anus, which being bent inwardly may be hid under the tail.
c The straight gut.
d d Three little testaceous bones on each side of the tail, which are articulated among themselves and with the bone.
e A small part of the intestine.
f The blind or closed gut, or what is anologous to it.
g g The appendages, which in the living creature are seen beautifully through it.
h h The origin of the appendages, which spring from two distinct ducts.
i i The appendages, whose situation was shewn at letter *g g*, are seen here separated.

FIG. VI.

One of the pair of legs separate from the rest, represented magnified, together with the genital vessel, entire, by which that leg is on one side, perforated.

1 2 3 4 5 The five articulations of the fourth pair of legs.
a a The winding of the genital vessel.
b b Its spiral windings which terminate in one narrow tube.

c The extremity of its end.

d The part in which the genital veſſel, after a wonderful manner, perforates the fourth pair of legs throughout the fifth articulation.

FIG. VII. and VIII.

The heart and one of the gills, repreſented as magnified.

a a The heart. *b* Four veſſels iſſuing from the upper part of the heart.

c Two other veſſels iſſuing from the lower part of the heart.

d Some blood veſſels diſcharged of their fleſh, and rolled out.

e One of the XXII gills.

f The thick and broad part of it

g The acute extremity.

h The diviſion of the gills.

N. B. *Thoſe white hollows or grooves, which run longitudinally through the middle of the gill, ſhew the cartilages, near which the blood veſſels are conveyed; in which part they appear thicker and whiter.*

FIG. IX. X. and XI.

The brain, ſpiral marrow, eyes, cornea, and inverted pyramidal fibres, repreſented as magnified, beyond their natural ſize.

a a The brain.

b b The optic nerves, one of which is laid entirely bare.

c The origin of the ſpiral marrow, which is ſeparated, and affords in the living inſect a paſſage for the gullet to the ſtomach.

d The firſt knot or ſwelling, with the nerves it emits.

e e e e e The remaining five knots of the marrow.

f f Nerves which ſpring from the marrow.

g Theſe nerves elegantly decuſſate one over the other, iſſuing from the right to the left, and from the left to the right ſide·

h Part of the cruſt as yet ſticking to the eye, near which the naked nerve is viſible.

i The cornea tunica, and the manner by which the annular cruſt like a tooth inſinuates itſelf into it.

k A gelatinous hexagonal matter placed within the eye, above the inverted pyramidal fibres, which appears on removing of the cornea.

l The inverted pyramidal fibres and their ſituation.

m The black part of thoſe fibres, which ſpring from the tunica uvea.

n The lower part of the fibres which appears brown.

o The middle part of them which is limped.

p p A certain part of thoſe fibres, enlarged by the microſcope, by which it appears, that each of theſe fibres conſiſts of many other ſmall fibres, all which are again compoſed of regular globules.

TAB. XII.

No. I. The vermicle or worm of the Libella or Dragon-fly, ſticking as yet in its firſt ſkin, when it is called an egg: repreſented magnified by the microſcope.

II. The egg itſelf, deſerted by the worm, repreſented of its natural ſize.

III. The worm, as come out of the egg, called, by this author, an Oviform Nymph-vermicle.

IV. The ſame worm a little more grown, when the follicles, or membranaceous bags of the four wings are obſerved to ſpring.

V. The ſame worm, perfect, with its four follicles or little bags, increaſed to their due ſize, called in this ſtate the Nymph-Vermicle.

VI. The Libella or Dragon-fly in its perfect ſtate, having attained its full age, and fit for generation.

FIG. I.

The egg of the Dragon-fly, as magnified by the microſcope.

FIG. II.

The Nymph-Vermicle of the Dragon-fly, caſting its ſkin.

a a The feet fixed with the claws.

b The head and eyes burſt forth.

c c The ſix legs, now cleared from their ſkins.

d d The wings, as yet folded up.

FIG. III.

Of the copulation of the Dragon-flies.

a the tail of the male.

b The female receiving into her neck the tail of the male, and embracing it with her legs.

c The tail of the female turned toward the breaſt of the male.

FIG. IV.

The nymph of the largeſt Dragon-fly.

a a The eyes. *b b* The horns. *c* The teeth.

d d The legs armed with ſharp claws.

e e The little bags, or caſes of the wings.

f f The diviſions of the abdomen,

g The ſtings, or prickles of the tail.

FIG. V.

The Nymph-Vermicle of the middle ſized Dragon-fly.

a The lips and teeth. *b* The hairy legs.

c The little bags, or caſes of the wings.

d The ſtings, or plickles of the tail.

FIG. VI.

FIG. VI.

The Nymph-Vermicle of a ſingular kind of a Dragon-fly.

a The horns. b b Six long legs.
c The little bags, or caſes of the wings.
d The hairy belly.
e The triangular appendages of the belly.

FIG. VII.

The Nymph-Vermicle of the ſmalleſt Dragon-fly, found common in Holland.

TAB. XIII.

FIG. I.

The Worm of the Ephemerus, of the firſt year's growth, three quarters of a Dutch inch long, in which is not the leaſt appearance of wings; but the five gills are viſible on the back, from whence come in ſight the ten lower rowing fins.

FIG. II.

The Worm of the Ephemerus of the ſecond year's growth, five thirds of an inch long; the little bags or caſes in which the wings are encloſed.

FIG. III.

The Worm of the Ephemerus of the third year's growth, a female, about two inches and a half long; provided with the little bags or caſes of the wings, which are now viſible.

FIG. IV.

The largeſt Worm of the Ephemerus, in which all the parts elegantly and diſtinctly appear,

a The eyes, which are twice as large as thoſe of the female worm.
b b The horns, and the diſtinct articulations of them.
c The forceps, mouth, or dentated jaws, by which they dig into the earth.
d d The firſt, ſecond, and third pair of legs, with their articulations or joints.
e The little bags or caſes of the wings, which encloſe the firſt pair of wings, like a tender little flower, ſhut up in its cup.
f f The gills, perpetually fluttering, very white and limpid, and covered with innumerable fine hairs.
g Three briſtly hairy tails, with their appendagee.
The rowing fins in *Fig.* I. and III. may alſo be ſeen.

FIG. V.

Oblong or hollow tubes, or cells, made in the mud or clay, in which the Worm of the Ephemerus creeps, and is moved and nouriſhed.

a a The tubes made in the mud by the largeſt worm.
b b The tubes that are hollowed out by the ſmalleſt worms.

FIG. VI.

The male Ephemerus freed from the firſt exuviæ, or ſkin, entirely ſtript of its former likeneſs of a Worm.

FIG. VII.

The Worm of the female Ephemerus, about to undergo in a little time its change, in which may be ſeen the wings through their little bags or caſes.

a a The little ſheaths, caſes, or bags of the wings, through whoſe ſmooth external little membranes may be ſeen diſtinctly, the folded wings lying hid within them.

FIG. VIII.

A female Ephemerus, ſtript, on the ſurface of the water, of its ſkin; and quitting the form of a ſwimming Worm is changed into a flying inſect.

FIG. IX.

The manner how the wings expand themſelves. But in the following XIVth *Tab. Fig.* I. *under let.* ε ε ε *may be ſeen the natural foldings of the wings, which here ſeparate by degrees one from another.*

FIG. X.

The ſame wing, firſt ſmoothing its ſerpentine foldings, afterwards its oblong folds.

FIG. XI.

The ſame wing not entirely expanded.

FIG. XII.

The male Ephemerus, employed in changing its ſkin, which is very ſlowly completed on dry land. Here half the body is now ſtript of its ſkin. The ſkin is ſtript off the head, thorax, and legs, in the ſame manner as we draw our feet out of our ſhoes; but as to the wings, the ſkin is drawn off them in ſuch a manner, that the inſide is turned outward.

FIG. XIII.

A male Ephemerus, which has almoſt gone through the change of its ſkin, ſo that its double external wings aud tail might be taken only for a ſlender part as yet to be caſt off.

FIG. XIV.

The very ſlender caſt ſkins of the Ephemerus, which do not retain the form, as here repreſented, becauſe the parts in which the wings were included, are commonly wrinkled, and by that means change the form.

FIG. XV.

FIG. XV.

A male Ephemerus, which has caſt both its ſkins, changed into a flying inſect; whoſe legs, which in the worm-ſtate were ſhort, are now as long again as they were, but the tails which were before twice that length, are now become three times as long.

TAB. XIV.

FIG. I.

A diſſection of the Worm of the Ephemerus.

a a The pulmonary tubes, or two air trunks, running along each ſide of the body.

b b The tubes reaching to the brain and nerves.

d d d d d The pulmonary tubes tending to the muſcles of the abdomen, from one ſide; but from the other ſide are ſeen, at the ſame letters, the naked muſcles of the abdomen, with their tubes, alſo the oblique, aſcending and ſtraight muſcles, hidden partly under the former.

e e e The air pipes, or tubes, running to the ſpinal marrow.

f f f f f f The air pipes diſtributed through the ſmall guts, or ſeminal veſſels of the male. One of them repreſented in its natural ſituation, and another of them removed out of the body, and repreſented magnified more than the other.

g g g g g The air pipes diſtributed to the gills. Only two of the gills are here repreſented, the other ten being cut off, to give an opportunity of ſeeing the ten rowing fins underneath them. See let. *r r r r.*

h The air pipes running to the loweſt parts of the inteſtines, and alſo to the ſpermatic veſſels placed near them. *γ γ.*

i i i The air pipes which ſupply, refreſh, and nouriſh the fat, membranes, and ſkin with air.

k k The air pipes.

p p p p Three exraordinary air pipes diſpatched beyond the body, towards the gills, cut off.

q q The middle of the three firſt pipes, being black, but about the middle ſhining with white, in ſuch a manner, that the black line of the gills appears as if marked with a white point oppoſite.

r r r r The five rowing fins ſtretched out from each ſide of the body, with ſtrong briſtly hairs, of an obſcure yellow gold colour,

s s A feathery little part ſituated underneath the firſt pair of gills.

y y y y The ſpinal marrow, conſiſting of eleven knots or ſwellings, from which ſpring the nerves that are diſtributed through the whole body. See *Fig.* VI. *Tab.* XV.

z z The parts to which the ſpinal marrow is faſtened, by the means of ſtrong ligaments.

** The optic nerves, derived from the brain, or origin of the ſpinal marrow, where it forms the firſt knot or ſwelling.

α α The muſcles of the breaſt, employed in moving the legs.

β β The muſcles of the breaſt, employed in moving :he wings, cut off.

γ γ Two little parts, which I take for the ſpermatic veſſels of the male.

δ The ſtraight gut cut off, in *Tab.* XV *Fig.* V. that it may be the more perfectly ſeen.

ε ε ε The extremely artificial folding of the wing, whilſt it yet lies in its caſe or ſheath, *k k.* being very eaſy to be unfolded. See *Fig.* IX. X. XI. *Tab.* XIII.

FIG. II.

All the parts juſt now repreſented in their natural ſize.

TAB. XV.

FIG. I.

l l Some branches of the air pipes which run to the ovary of the Ephemerus.

m m m m The ſame air-pipes running into and over the membrane inveſting the ovary.

c c The muſcles employed in moving the ſix gills and five rowing fins, placed on each ſide of the body.

f f The ſtomach and inteſtines, which are viſible through the membranes of the ovary. See *Fig.* V. of this Table.

i i The muſcles of the ſtraight gut employed in voiding the feces.

FIG. II.

The little eggs of the Ephemerus, as they appear to the naked eye.

FIG. III.

The double ovary of the Ephemerus, conſiſting of innumerable little eggs.

FIG. IV.

o o o o Some air pipes leading to the heart of the Ephemerus, partly cut off.

t t Part of the heart, like an oblong tube, which is ſomewhat ſwollen on each ſide.

v v v v Some air pipes cut off, leading towards the heart, and then to other parts.

x x x x The parts in which the tube of the heart ſwells up a little.

FIG. V.

a Part of the oeſophagus or gullet, cut off near the ſtomach

b The pylorus of the ſtomach

c The ſtomach itſelf, with certain air pipes, which creep all over it.

d d The ſmall gut continued from the ſtomach.

e The thick gut or colon, diſtinguiſhing itſelf by ſome little oblong tranſparent channels or furrows.

f The

f The ſtraight gut elegantly folded, or wrinkled.
g Certain ſemilunar little valves of the ſmall gut.
4 5 6 7 8, *&c.* Eleven annular ſections, into which the body is divided.

FIG. VI.

The brain, ſpinal marrow, and the nerves, ſpringing from thence, according as they are placed in the living Ephemerus.

1 2 3, *&c.* The natural ſituation of the ſpinal marrow in the body of the Ephemerus. At the ſame time is ſhewn how the annular interſections are placed.

FIG. VII.

n Air pipes together with a part of the ovary, drawn out of the body, the more conveniently to ſhew how theſe pipes ſtick faſt to the eggs.
g The eggs, of a plain round oblong figure.

TAB. XVI.

No. I The Ant's egg delineated in its natural ſize, or the Worm of the Ant in its firſt ſkin or coat, wherein it is called an egg; which is exhibited in the firſt figure magnified.
II. The beforementioned covering, being quitted by the Worm of the Ant, is rolled up as into an inviſible point.
III. The Worm of the Ant come forth from the egg, with its parts imperfect; delineated in its natural ſize and ſituation. Figure the ſecond repreſents it magnified by the microſcope.
IV. The ſame Worm at the full period of its increaſe, all the parts of the Ant being contained hidden within it. Figure the third ſhews it as magnified.
V. The ſame Worm ſtript of its ſkin, and now called a Nymph.
VI. The ſame, having quitted the form of a Nymph, changed to a real and perfect Ant.

FIG. I.

The egg of the Ant magnified.

FIG. II.

The Worm of the Ant, as delineated under the microſcope, with its head bent towards the breaſt; called improperly the egg of the Ant.

FIG. III.

The former Worm, having arrived at its full bigneſs, about to quit by and by it skin, in order to be changed into a Nymph. This is alſo larger than naturally.

FIG. IV.

The Nymph of the Ant delineated by the aſſiſtance of the microſcope, which is repreſented No. V. *in its natural ſize.*

FIG. V.

The ſame Nymph, lying on its back, magnified.

FIG. VI.

The ſame Worm delineated again, as it appears under the microſcope; and all it parts diſtinguiſhed by annexed letters.

a a The two eyes in the head. *b* The teeth.
c c The horns, folded near the legs, upon the breaſt.
d d The firſt pair of legs.
e e Another pair of legs, viſible under the firſt.
f f The third pair, laid on the belly.
g The rings of the belly, and margin or border of the belly.

FIG. VII.

The Ant having completed all its labours, and now attained the full maturity and ſtrength of it age, exhibits the number of its parts and limbs complete.

a The teeth of the Ant, in which it carefully carries its Vermicle, or little Worm.
b b The two very black eyes.
c c The horns, of a light red colour.
d The ſix ſharp pointed prominences, into which the rings of the thorax divide themſelves.
e The loins, conſiſting, as it were, of three knotty joints or vertebræ.
f f Six hairy legs, compoſed of four joints.
g The ſhining hairy abdomen.

FIG. VIII.

The male Ant, in its natural ſize.

FIG. IX.

The male Ant, delineated as magnified, in which all the parts are diſtinctly repreſented.

a The teeth, a little leſs.
b The eyes, on the contrary, larger.
c c The horns.
d d Four wings, peculiar to the male, the firſt pair of which are much ſtronger and larger than the hinder ones.
e The loins, and
f The belly are both differently formed than thoſe parts are in the working Ants.

FIG. X.

The female Ant, in its natural ſize.

E FIG. XI.

FIG. XI.

The female Ant, represented magnified; that the external difference between it and the other kind may be made to appear.

a The teeth. *b b* The eyes.
c c The horns. *d* The thorax.
e e The legs. *f* The loins.
g The belly.

FIG. XII.

The little bag or case, in which the Worm of the Ant, being shut, is changed into a Nymph; as yet entire, and of its natural size.

FIG. XIII.

The same, opened.

FIG. XIV.

Another kind of Ant, found in Holland.

FIG. XV.

A sixth kind of Ant, found also in Holland.

FIG. XVI.

The largest kind of Ant, found at the Cape of good Hope.

TAB. XVII.

Which represents Bees.

FIG. I.

The common or labouring Bee, whose external parts, are particularly described in the following figure.

FIG. II.

The same labouring Bee, in which all its external parts are distinctly pointed out by annexed letters.

a a The two oval eyes of this Bee, which are much smaller than those of the male Bee.
b The particular little eyes, placed in the middle between the two former larger ones.
c c The antennæ or horns.
d A kind of horny or bony lip, which is not obvious in the males.
e e Two long teeth, which are shorter in the female, and very small and short in the male Bees.
f The long proboscis or trunk, which is much shorter in the male.
g The thorax is roundish, and in the upper side of the hinder part it is provided with a somewhat prominent margin or border.
h h The two upper wings.
i i The two lower wings, which are less than the former.
k k The two foremost legs.
l l The two middle legs.
m m The two hinder legs, larger than the former ones, and that particular part of them which we call the foot.
n n The claws of the feet.
o o Part of the hinder legs, which is called the shank, the foot of which of one extreme part, is joined to another part called the thigh.
The abdomen. *q* The aculeus or sting.

FIG. III.

The female Bee, commonly, but improperly, called the king. By comparing this with the common or working Bee, represented in the last figure, and with that of the male in the following figure, the difference between the three kinds may be observed.

FIG. IV.

The male Bee, which differs from both the female and working Bee.

FIG. V.

The proboscis of the Bee, with its parts as represented by the microscope.

a a The first pair of joints of the proboscis, which are partly of a substance between horn and bone, and partly of a membranaceous substance, and here and there are covered with rough hairs. This cut represents them a little drawn in, and in readiness to move the proboscis backwards, and withal to compress and cover it; and likewise to force the honey through it towards the stomach.
b b The air-tubes, distributed through that part of the proboscis, which is of a substance between horn and bone; and which, by being transparent, affords a view of them.
c c The extremities of the first pair of joints; these extremities are a little crooked.
d d The articulation of these joints with the root of the proboscis.
e e The next pair of joints belonging to the proboscis, constructed much after the same manner with the first. This second pair greatly assist the proboscis in its suctions.
f f The lower articulation of these joints, of a pretty considerable length.
g g The two upper articulations of the same joints, which are shorter.
h h The third pair of joints forming the proboscis, which are somewhat of a substance between bone and horn, but for the greatest part membranaceous, and likewise covered with rough hair. These joints also are of service to the proboscis in sucking the honey, which

which they likewife help to forward towards the ftomach.

i The feventh joint of the probofcis, being a fingle one; or the probofcis itfelf, confifting partly of a membranaceous fubftance, and partly of a fubftance between bone and horn. It is the underfide of it that I have here reprefented, as it may be fuppofed to appear, on turning the Bee upon its back.

k k Part of the probofcis itfelf, of a fubftance between bone and horn, conftructed in fuch a manner, that the Bee can feperate it from the main body of the probofcis, and give it a circular form.

l The gullet reprefented cut off.

m The membranaceous part of the probofcis itfelf, which lies beautifully folded up under the other portion of the probofcis juft now mentioned, as confifting of a fubftance between bone and horn.

n n The part of the probofcis which confifts of a fubftance between bone and horn, tending inwardly, and forming, as it were, a narrow channel.

o o The fore extremity of the probofcis covered with crooked hairs, and furnifhed with a little head, in which there is a hole that feems to be the cavity of the membranaceous part.

p That part of the probofcis, which confifts of a fubftance between bone and horn, divided at its fore extremity into two fhanks.

q q q Three very black, but fhining, joints of the probofcls, of a fubftance between bone and horn, and forming the lower part of the probofcis. The middle of thefe joints is the fheath or cafe of the probofcis, and is furnifhed with mufcles, which belong to the fecond pair of joints *e e* of this organ. But the two extreme joints of the part now before us, contain mufcles that adminifter to the firft pair of joints *a a*.

r r r r The articulations by which the three joints *q q q* are united with the parts of the head.

s s The ftrong mufcles ferving to move inwards the probofcis, its joints and fheath.

t A thin tranfparent membrane, through which the mufcles *s s* may be difcerned.

FIG. VI.

More diftinctly exhibiting in what manner that part of the probofcis, which confifts of a fubftance between bone and horn, and which is reprefented under the letters k k Fig. V, *can form itfelf into a circle, and dilate the membranaceous parts of the probofcis at the time of its fuction.*

a a a That portion of the probofcis, which confifts of a fubftance between bone and horn. This part is much blacker and ftronger in the middle of it than elfewhere, as is very difcernible.

b The circular form or bending which that part acquires at the time of fuction.

c c c c The expanfion, in form of a fail, of the membranaceous part of the probofcis, that lies folded up under the other part that confifts of a fubftance between bone and horn. The former part acquires the faid form, when the latter projects itfelf in that of a circle.

d The papillæ, or glandalous protuberances of the membranaceous part of the probofcis. Thefe particles appear moft vifible when the faid part is expanded.

e The place where that part of the probofcis, which confifts of a fubftance between bone and horn, tends inwardly, and uniting with the remaining hairy part of the probofcis, forms, as it were, a narrower channel.

f The fore extremity of the probofcis, covered, as it were, with crooked hairs, and perforated in the middle.

g The hairs of the probofcis, which are not of an equal thicknefs, but fomewhat bigger near the roots.

FIG. VII.

The probofcis of a Wafp, viewed on its lower fide.

a Part of the probofcis of a horny fubftance, which conftitutes the lower part of the infect's head. This part is covered with hair on its fides, and is all of a fhining black, except two yellow fpots.

b b c Three horny particles or joints, which ferve in a manner to form the root of the probofcis. The two lateral *b b* contain the mufcles, that govern the briftles *d d*; but the middle joint *c* ferves, as it were, for a cafe or fheath to the probofcis.

d d d d Four articulated briftles, which affift the probofcis in its fuctions.

e e The place where the teeth are broken off.

f The probofcis itfelf, adorned with four beautiful white particles, or rather protuberances, that terminate in little round knobs.

FIG. VIII.

The hair of a Bee, as it appears through the microfcope, in the form of a feather.

a The ftem, as it were, of the feather.

b b The fmaller lateral branches fpringing from the ftem.

c The hairy extremity of the ftem.

FIG. IX.

The lungs of the Bee.

a a The pulmonary veficles of a white colour.

b b &c. The little tubes branching from thefe veficles; they confift of fpiral rings, which in this place are always open.

c c &c. Other veficular dilatations of the pulmonary

monary tubes, which again degenerate into the tubes *d d &c.*

e e &c. Ramifications of the pulmonary tubes diſtributed through the body.

f f Two places, where the greater pulmonary veſicles have a direct communication with each other.

FIG. X.

The pulmonary tube, which conſiſts of rings, and is here repreſented as it appears when drawn out, the better to exhibit the ſpiral courſe of theſe rings.

TAB. XVIII.

FIG. I.

The internal parts of a Bee.

a The gullet.

b The ſtomach, furniſhed with fleſhy fibres.

c The pylorus, conſiſting of nodules, and full of a ſubſtance of a yellowiſh red colour.

d d The ſmall gut, very ſpacious or wide, full of muſcles, and furniſhed with valves.

e e e The vaſa crocea, or yellow gut-veſſels; being an infinite number of little inteſtines moſt intricately connected, and moſt firmly united with the narroweſt part of the ſmall gut.

f The narrow part of the inteſtine.

g The ſudden dilatation of the inteſtine, that ſucceeds the conſtruction of it juſt now mentioned. In this place the inteſtine looks like a membrane, and exhibits ſix protuberant glandulous particles on its inner ſurface, as beſt appears by the particular figure placed at one ſide of that now under our conſideration.

h h The ſaid ſix glandulous particles, as they appear more plainly on opening the inteſtine that contains them.

i The place where the inteſtine, after dilating itſelf, narrows a ſecond time. I have given a particular figure to illuſtrate this narrowing.

k The place where this inteſtine appears full of folds, like a rumpled piece of linnen.

l The ſtraight gut, over which the ſting lies.

m m The hinder part of the laſt abdominal ring, which is covered with hair, and gives a paſſage to the ſtraight gut.

n n Six particles or joints, of a ſubſtance between bone and horn, which are articulated with the ſhanks of the ſting.

o o Two appendages always found along with the ſting, and placed on each ſide of the ſting and the ſtraight gut.

p The bag containing the poiſon, which the Bee injects into the wound made by the ſting.

q q The blind extremities of the tube that ſerves to ſecrete the poiſon, and afterwards conveys it to the bag that is to contain it.

FIG. II.

Repreſenting the ſting, and all its parts.

a The ſting, compoſed of a ſheath or caſe, and two ſhanks, united to each other, and terminating in a ſharp point, ſo as to look like a ſingle part.

b The poiſonous bag.

c The tube that ſerves to convey the poiſon from its bag, to the thickeſt part of the ſting's ſheath.

d d The two ſhanks of the ſting, mutually conveying to each other.

e e The ſheath of the ſting.

f f The thickeſt end of the ſheath, where the tube opens into it, by which it receives the inſect's poiſon.

g The extreme point of the ſting, formed by the two ſhanks of that organ, that are in this place cloſely united.

h h The beards with which the ſhanks of the ſting are armed at their extremities.

e The tube that ſerves to ſecrete the poiſon, which it diſcharges into the poiſon-bag.

k k The two blind extremities of ſaid tube.

l l l l l l Three pair of cartilages, of different forms, which are for the moſt part of a deep black, and articulated among themſelves, and with the ſhanks of the ſting.

m m Two other cartilages leſs conſpicuous than the former, with one pair of which they are articulated. Theſe two cartilages *m m*, are almoſt entirely of a membranaceous ſubſtance.

n n n n n n n n Eight places in which the foregoing cartilages are articulated among themſelves, and with the ſhanks of the ſting *d d.*

o o o o Four muſcles ſerving to move the ſting different ways, by the aſſiſtance of the ſame cartilages.

p p Two muſcles which draw the ſhanks of the ſting into its ſheath.

q q Two appendages of the ſting which are moved along with it, and ſeem to anſwer no other purpoſe but that of ornament.

FIG. III.

Which again exhibits, but in a more diſtinct manner, the ſting and other parts relating to it.

a The thick or blunt extremity of the ſting's ſheath, into which the inſect ſheds its poiſon.

b The ſharp extremity of the ſting's ſheath, to which the poiſon runs, under the ſhanks.

c c The place where the channel of the ſheath grows narrower, the better to retain the ſhanks that are within it, in their proper ſituation. This particular may be ſtill better diſcerned under the letters *d d.*

d d The ſhanks of the ſting laid up within the channel of the ſheath, and beautifully retained in their proper ſituation by the two proceſſus of the ſheath, already taken notice of under the letters *c c.*

e e e The borders or edges of the ſting's ſheath, which are turned in, and received by the channels of the ſting's ſhanks, and not only ſerve to retain the ſting in it's ſheath, but likewiſe allow it leave to move freely.

f One

f One of the fting's fhanks put fomewhat more forward within the fheath than the other fhank; but after fuch a manner, however, that the fting's point ftill remains entirely within the fheath.

g The other fhank of the fting, lying higher within the fheath. We may here fee by what means the fting, left in the wounds made by it, penetrates deeper and deeper.

h The hollow, cavity or channel of the fting's fheath, when wideft.

i The narroweft part of the faid hollow, cavity, or channel.

k One of the fting's fhanks reprefented by itfelf, fo as to exhibit

l l The cavity or channel within which the edge of the fheath is received, fo as to afford the fhank a free motion.

m A fegment of the fhank cut off tranfverfely, to give a better view of the fhank's cavity or channel.

n The fame channel or cavity, as it appears in the other branch.

o The extremity of the fhank's channel or cavity.

p Ten crooked heads or beards, with which each fhank is generally furnifhed.

q q q Other lefs confiderable hooks or beards.

r r r Certain proceffes of a fomewhat cartilaginous fubftance, and ferving, inftead of mufcles, to move the fhanks.

s s s The fmooth unbearded fides of the fhanks, by which they join each other.

t t t The hinder parts of the fhanks, or the ligaments by which they are thruft out.

v v Two places in which the fting appears as if there was a joint in it. But this appearance is entirely owing to the air, which makes it appear uneven: the poifon fticking to the fheath.

x The poifon bag.

y The tube which conveys the poifon of the bag.

z The tube by which it difcharges its poifon.

FIG. IV.

The poifon bag of the Wafp, and the Hornet, with the other parts belonging to it.

a The poifon bag

b The tube by which the faid bag fheds its poifon.

c c The two tubes inferted into the hinder part of the poifon bag, into which they difcharge the poifon. In the Bee there is but one tube to anfwer this purpofe.

d d d Swellings here and there in the laft mentioned tubes.

e e The ends of the tubes fomewhat thicker than any other part.

FIG. V.

Reprefenting the manner, in which the Bee's poifon may be extracted or gathered.

a A flender glafs tube ferving to receive the poifon.

b The point of the fting placed within the tube, and pouring into it the poifon fqueezed by the fingers out of the poifon-bag.

TAB. XIX.

FIG. I.

The Bee's heart, with the parts belonging to it.

a a Part of the heart feated in the upper region of the abdomen.

b b b Pulmonary tubes running towards each fide of the heart, in which they at laft terminate.

c c c c c c Certain thin membranes, that ferve to keep the fat in its proper place.

d d The fat as it appears through the faid membranes, which are tranfparent.

e e e The ovary, as it likewife appears through the faid membranes.

f f f f f The mufcular fibres broken off from the abdominal rings, which they ferve to govern.

1 2 3 4 5 6 The fix abdominal rings under which the heart is placed, as it were in the infect's back.

FIG. II.

The ovary of the Bee, of the fize and form it appears to the naked eye.

FIG. III.

The fame ovary, reprefented as it appears through the microfcope.

N. B. This double ovary is compofed of parts extracted from two different female Bees, *viz.* The part *a* from a full-grown impregnated Bee; and the part *c* from another Bee lefs perfect, and not as yet impregnated. This I did to avoid the neceffity of two figures, where I thought one might be made to anfwer.

a Part of an ovary extracted from an impregnated Bee, furnifhed with an infinite number of ducts, that contain eggs of different fizes.

b b The coalition of the oviducts of each fide, where they difcharge their eggs into a common channel or duct for all the eggs of that fide.

c Part of an ovary extracted from a female unimpregnated Bee. The eggs of this part differ greatly from thofe of the other part *a*.

d A dilatation of the pulmonary veficle, which diftributes its ramifications, and an infinite number of air-tubes through every part of the ovary, its ducts, and even the eggs themfelves.

e e The upper parts of the oviducts of an impregnated Bee, where they unite, and the two parts of the ovary bend towards each other.

f f The upper parts of the oviducts of an unimpregnated Bee, in which they are hereabouts very ſlender, contain but very minute eggs, but which bend in the ſame manner mentioned in the preceding article.

g g The eggs of the ovary of an impregnated Bee, which are ſenſibly bigger and bigger, the nearer they approach the common oviduct of the ſide, to which they belong.

h h h The eggs of an impregnated Bee, which are in every oviduct almoſt of the ſame ſize, at the ſame diſtance from the common oviduct.

i i i The eggs in the extremities of the oviducts of an unimpregnated Bee's ovary. Theſe eggs are not only very ſmall in themſelves, but ſmaller, paler, ſhorter, and more delicate than thoſe in the extremities of the impregnated Bee's ovary.

k k k k k k The eggs in both parts of the ovary, ready to fall into the greater common duct.

l l l l The eggs of an unimpregnated Bee, differing in ſize, but very irrregulary, ſome of thoſe furtheſt from the common duct being bigger than the others that are much nearer, contrary to what appears in the impregnated Bee, as has been already obſerved under the letters *g g h h.*

m m The eggs in the extremity of an impregnated Bee's ovary, which are bigger, and of an oblong, and more regular form.

n n Two common ducts, or, as it were, the horns of the uterus, in which all the particular oviducts terminate, and pour their eggs.

N. B. Both theſe ducts are extracted from an impregnated Bee, though one of them ſupports the ovary of an unimpregnated one.

o o The place through which the ſpinal marrow takes its courſe.

p p Part of the common duct, more ſpacious than the reſt, furniſhed with muſcles, or of a muſcular conſtruction, and within which are placed

q q q q q q A great number of eggs ready to come away; theſe eggs appear a little through the duct, which is tranſparent.

r r r r r Air-tubes, running through the horns and the common duct of the ovary.

s The coalition of the two common ducts or horns into one narrower channel, which is likewiſe muſcular, and the excretory duct of the Bees eggs.

t A globular or little round part or organ, containing a glutinous matter, with which the eggs are ſmeared over before the Bee lays them. The interior coat of this bag is curiouſly interwoven with an infinite number of air-tubes.

u u Two blind veſſels, that, after making a great many turnings, meet, and form a ſingle tube. This tube terminates in the uterus, or excretory duct of the eggs, and ſerves perhaps to ſecrete the glutinous matter juſt now taken notice of, and to convey it to the bag deſtined to receive it.

x The exitus, or end of the uterus, or of the excretory duct of the eggs, as yet not ſufficiently examined.

y y The external muſcular parts of the ſting, broken off.

z The poiſon-bag, with

α Its ſingle ſecreting tube, and

β β The blind appendages of the ſaid tube.

γ The tube by which the poiſon is diſcharged.

δ The ſting of a female bee, naturally crooked.

ε ε Two little parts placed by the ſides of the ſting, and already taken notice of in the anatomy of the working Bee.

ζ The ſtraight gut.

FIG. IV.

The ovary of a Waſp.

a a The oviducts of this ovary repreſented by themſelves, being ſeven of a ſide.

b b b The upper part of the ovary, extending to a very great length.

c The bag containing a glutinous matter, with its ſecretory veſſels. This bag is ſhaped like a pear.

d d Some minute eggs, of the common oval form.

e The meeting of the particular oviducts in one common oviduct.

FIG. V.

The egg of a Bee, repreſented by itſelf.

a The egg, of its naȝnral ſize.

b The ſame egg ſeen with the microſcope, which ſhews an infinite number of air-veſſels, diſtributed all over the egg's ſurface.

c c The oviduct cut off at each end of the egg.

FIG. VI.

The poiſon-bag of the Bee, of its natural ſize.

b The poiſon-bag repreſented under the letter *z* of Fig. III. as it appears through the microſcope.

c c Two blind appendages which ſerve to ſecrete the poiſon, and afterwards meet ſo as to form

e A ſingle tube, terminating in the body of the bag.

TAB. XX.

FIG. I.

The head of the Male Bee, with the parts belonging to it, eſpecially the eyes, which are here repreſented much bigger than in nature.

a Three ſingular, or particular unequal eyes,

eyes, which in the male Bee are placed in the form of a triangle between, but lower than the greater eyes; but in the female and working bees, theſe unequal eyes appear in the upper part of the head.

b b One of the greater eyes, eſpecially the ſuperior external face of it, which is by no means pointed, but of a roundiſh form.

c The internal inferior edge of the greater eye, which is ſomewhat pointed, ſo as to leave an intermediate ſpace for the reception of the ſmaller eyes, and other parts.

d Feathered hairs, or hairs in form of feathers, growing in the ſpace between the greater eyes.

e e e Hairs with which both eyes are well ſupplied, and which too anſwer the purpoſe of eye-brows or eye-lids.

f f The Antennæ or little horns.

g g Fibres of an inverted pyramidal and hexagonal form, which immediately appear on removing the cornea, and uvea of the eye.

h h The upper part of the ſaid pyramidal fibres of a pretty conſiderable breadth.

i The lower part of the ſaid fibres, where they terminate in a point; likewiſe the internal coat of the eye, upon which theſe fibres ſtand.

FIG. II.

The diſpoſition or ſituation of the hexagonal diviſions of the cornea.

k k A hexagonal diviſion encloſed by ſix other ſimilar diviſions; and this order, or diſpoſition, or arrangement, obtains all over the cornea, and all its diviſions.

FIG. III.

A ſmall portion of the Cornea, along with its hairs, as ſeen through the microſcope.

l l l The thickneſs of the cornea, which is pretty conſiderable.

m m m Hairs like briſtles, growing out of the Cornea, which they even perforate with their roots. Theſe hairs project a conſiderable way beyond the ſurface of the cornea, and anſwer the purpoſes of eye-brows and eye-lids.

FIG. IV.

The cortical lower fibres of the eye.

n n n The cortical fibres of the eye, which lie like beams or joints on the membranes that ſupport the upper pyramidal fibres.

o The manner in which theſe fibres are placed one over another, like beams intended to form a raft.

p The brain, ſituated under theſe fibres, and communicating with them.

FIG. V.

The eyes and brain, as they appear on beginning the diſſection of them on the lower ſide.

q q The cortical fibres of the eye, ſhewing in what manner they lie tranſverſely or acroſs, under the membranes, that ſupport the pyramidal fibres, and are diſtributed like the muſcular fibres in the papillæ of the kidneys.

r The origin of the ſpinal marrow.

s s The cortical ſubſtance of the brain divided in the middle, and covering in part the cortical fibres of the eye.

t t The manner in which the cortical ſubſtance of the brain, communicates at each ſide with the ſpinal marrow.

u u The thickeſt part of the cortical fibres, and the place where they have the moſt apparent colour.

x The internal coat of the eye, ſupporting the inverted pyramidal fibres.

y The firſt nodule or ſwelling, formed by the ſpinal marrow, after its leaving the ſkull.

z z The pyramidal fibres of the eye, as they appear on each ſide, when juſt diveſted of the cornea.

FIG. VI.

The brain more accurately diſplayed.

a a The cortical ſubſtance of the brain, ſhewing, not only in what manner it communicates with, but likewiſe ſprings from the brain.

b The ſecond pair of the particles of the brain, from which the cortical ſubſtance derives its origin.

c The firſt pair of the brain's particles, from which iſſue *d d* Bipartite nerves.

e e The fourth pair of the brain's particles, ſhewing likewiſe in what manner the particles of every pair communicate with each other.

TAB. XXI.

FIG. I.

The genital parts of the male Bee, as they appear through the microſcope,

a a The two teſticles.

b b The vaſa deferentia, twining or curling like the tendrils of a vine.

c c The ſame veſſels conſiderably dilated, ſo as to appear like a ſecond pair of teſticles. Theſe veſſels are hollow.

d d The ſeminal or ſeed bags, into which the vaſa deferentia, after growing narrower again, are inſerted on each ſide.

e e The nervous root of the penis.

f A

f A little part or particle of a fubftance between bone and horn, of a deep brown, fomewhat inclining to red, placed within the oval tube, wart or tubercle of the penis.
g The penis, or part like a penis, but without any perforation.
h A fmall part divided into five divifions.
i Another particle, feated, as it were, oppofite to the former *h* but without any divifions. This particle is fhaggy on its infide, rugged, and full of wrinckles.
k k Hollow, pointed appendages.
l l Ligaments, ferving to faften the genital parts in the abdomen,
m A portion of the fpinal marrow, from which proceed
n n The nerves, that are diftributed over the genital parts, and ferve to move them, as likewife the purpofes of fecretion and pleafure.

FIG. II

o The genital parts of the male Bee, of their natural fize.

FIG. III.

The genital parts of the male Bee, beginning to unfold themfelves

c c The vafa diferentia cut afunder in their thickeft part, to fhew their thicknefs and cavity.
d d The feminal bags cut afunder for the fame purpofe.
e e The nervous root of the penis.
f f A little horny bone, fituated in the bulbous portion of the root of the penis.
h The five-fold little particle, beginning to unfold itfelf.
i The other particle, without any divifion, beginning likewife to unfold itfelf.
k k The fharp, hollow appendages coming out of the body
q q The horny bone, conftituting the extremity of the pudendum,
s s Certain particles ferving as ornaments to the faid bone.

FIG. VI.

The genital parts of the male Bee, a little more unfolded.

e The nervous root of the penis.
f The little horny bone placed within the tubercle of the root, further thruft out.
h The quinque fida, or five-fold particle further thruft out.
i The other particles without divifions, alfo more thruft out.
k k The fharp, hollow appendages quite unfolded from their roots, but
l l Their points ftill continue out of fight.
q q, *r*, *s s* } Denote the fame parts, as in the laft figure.

TAB. XXII.

FIG. I.

The genital parts of the male Bee, ftill further thruft out.

e The nervous root of the penis.
f The little horny bone lying within the tubercle of the root.
h The five-fold particle ftill more unfolded.
i The other particle, that has got no divifions, further thruft out.
k k The hollow appendages quite inverted, or turned infide out.
q q, *r*, *s s* } Denote the fame parts, as in the figure of the laft plate.

FIG. II.

The fame parts yet more unfolded.

e The root of the penis beginning to grow ftraighter.
h h The five-fold particle quite unfolded, and exhibiting its five divifions.
i The other undivided particle entirely difplayed in like manner.
k k The appendages perfectly inverted, or turned infide out, and ftiffened.
q q, *r*, *s s* } Denote the fame as before.

FIG. III.

The genital parts of the male Bee unfolded to their utmoft extent.

e The root of the penis extended, for the moft part within the pudendum.
f The little horny bone feated in the tubercle of the root, now entirely thruft out of the body, and appearing through the tranfparent parts which enclofe it. The five-fold particle, is now fo much dilated, as to be almoft out of fight, by lying backwards upon the hairy part of the pudendum.
g The penis, or particle refembling one, now perfectly inverted, or turned infide out.
i The undivided pyramidal particle in like manner unfolded and difplayed.
k k k The appendages as before, perfectly unfolded, and turgid withall.
q q, *r*, *s s* } The fame parts as before.
t The head of the peniform particle beautifully plaited.

u A

u A confiderable opening, or perforation under the penis, and at the bottom of, and between the divifions of, the little horny bone. already fo often taken notice of. The Bee's feed iffues copioufly at this opening.

FIG. IV.

x The head of the peniform particle, which, however, has no opening, and affords no paffage to the feed.

FIG. V.

The genital parts of the greater Hydrocantharus, or Water Beetle.

a The penis.
b b The horny part of the penis, ferving to faften it on each fide.
c c The root of the penis,
d The other tefticle in its natural fituation.
e The tefticle ftripped of its air tubes, fo as to exhibit its internal ftructure.
f f The vafa diferentia.
g g The thickeft part of the faid veffes.
h h h h h h Seven blind veffels rooted in the penis, and anfwering perhaps the purpofe of proftata.
i i The feed bags neatly curled at their extremities.

FIG. VI.

The fpinal marrow of a male Bee, feen through the microfcope

a The origin of the fpinal marrow.
b b 1 2 3 4 5 6 7 Seven nodules, formed by the faid organ in its progrefs, and the nerves iffuing from the faid nodules.
c c c c Some nerves which fpring not from the nodules, but from the branches themfelves of the fpinal marrow.
d a d d, &c. Clefts, or longitudinal perforations in the fpinal marrow.
e That part of the fpinal marrow, which lies in the head and neck.
f That part which lies in the thorax.
g That part which lies in the particle joining the thorax and abdomen.
h The abdominal part of the marrow.
i i Two confiderable nerves diftrubuted to the jaw bones, and other parts.
k k Two nerves running to the probofcis. Thefe are perhaps the infect's guftalory nerves.
l l Two other nerves, adminiftering to the guftatory nerves of the probofcis.
m m Two nerves, perhaps the optic ones; but I advance this with diffidence.
o o Two ftrong nerves, diftributed to the genital parts.

FIG. VII.

Part of the fpinal marrow, as it appears under a greater magnifier.

p p p p p p The branches, or ramifications of the fpinal marrow, and the nerves cut away from about the nodules.
q q q q The external fubftance of the marrow, refembling as it were a cleft or divided nerve.
r Another part of the marrow lying between the medullary fubftance, and forming the nodules.

TAB. XXIII.

FIG. I.

The ichnography of a regular honey-comb of the working Bees, as it appears, when infpected from above, divided into its regular hexagonal fections. This defcription could not be accurately fketched out, without the affiftance of fome artificial lines.

a A regular hexagonal cell, formed by artificial lines.
b b Double tranfverfe lines, ferving to determine the angles of the cells.
c c Longitudinal lines croffing the former.
d d Conftitute the fides and diameters of the cells.

FIG. II.

Four cells of the working Bees, feparated from the other cells.

a Three cells joined fide by fide to each other, and forming by the union, or meeting of their bafes, a cavity exactly fitted to receive.
b The bottom of a fourth cell, in cafe the Bees fhould build one. Thus it may be feen, in what manner three cells, built one clofe to another, form by the fides of their bottoms a foundation for fupporting the bottom of another cell, to be built a contrary way.
c Part of a triangular foundation floping downwards, and of the cell built upon the faid foundation. This is formed by the meeting of the fides of two cells.
d d Two pretty long, or longer and unequal angles, or corners, formed by the hexagonal fides of the fame cell, and uniting with the former part *c*, fo as to form the foundation of another cell.

FIG. III.

A fingle, regular, hexagonal cell cut lengthwife through its centre.

a One entire third of the foundation, that is cut into two by this fection.
b b The third part of a foundation, which foundation is cut away. One fegment of this foundation remains united at one fide with the third part laft mentioned, and the other fegment with the third part mentioned of the divided cell.

c The entire remaing third part of the divided foundation, ſticking to part of another cell.

1 2 3 4 5 6 The ſix ſides and angles or corners of the cell, as they mutually anſwered one to another.

FIG. IV.

Fifteen regular hexagonal cells, cut lengthwiſe on each ſide.

a b The upper cells. *c* The lower cells.

d The common foundation of the upper and lower cells, cut off.

e e e e The ſhorter ſides of the cells.

f f f f The longer ſides of the cells.

g The third part of a triangular foundation ſloping inwards, in its natural ſituation.

FIG. V.

A building, conſiſting of a great many cells for the reception of males and females, in order to ſhew in what particulars the ſaid cells differ one from another, and from the cells of the working Bees.

a The cell, or little houſe, of a female Bee, falſly called a king-Bee. This cell reſembles a pear, is irregularly built, with hollows here and there on its external ſurface, and is placed above the other cells.

c Cells of male Bees, one third bigger than thoſe of the working Bees. They are here repreſented ſomewhat bigger than nature, the better to ſhew the difference.

d The triangular foundation of the ſaid cells, which appear the better by removing the cells themſelves.

e Triangular cavities, formed each by three ſimilar cells of an oppoſite ſide or row, that are built one againſt another. Theſe cavities receive the bottoms of the cells of the ſaid ſide or row, in the ſame manner with the cavities in the conſtructions of the working Bee, already taken notice of.

f Two cells, whoſe fore edges are ſo covered and faſtened with wax, that their hexagonal form cannot be ſeen.

g Four very irregular cells, forming a foundation for the king's cell. Theſe four cells ſerve, perhaps, no other purpoſe but that of keeping honey.

FIG. VI.

Four regular cells of the working Bees, built one cloſe to another, after ſuch a manner, that they all ſtick to one common or intermediate foundation, at the ſame time that five of them lie to the right, and the other five to the left.

a Five cells belonging to one ſide. Theſe cells taken together are an inch long, are joined to each other by their ſides; and their bottoms lie contiguous to, and ſupport, the cells of the oppoſite ſide.

b Five cells of the oppoſite ſide, of the ſame length with the former, and united to, and ſupporting them in the ſame manner.

c c The intermediate foundation, that ſerves as a common bottom to the cells on each ſide.

FIG. VII.

A ſingle, regular, hexagonal cell of a working Bee, divided into three parts; the better to ſhew in what form they are conſtructed.

a a a Three longitudinal ſegments of a cell, each of which contains two ſides and one angle.

1 2 3 The three undivided corners formed by the ſides of the cell.

44, 55, 66 The three divided angles that were formed by the ſeparated ſides.

b The bottom of the cell, divided in like manner into three parts; theſe parts united form a hollow triangular ſloping foundation. We may here ſee, how every two ſides of a cell form one part of a triangular bottom.

FIG. VIII.

Nineteen regular hexagonal cells built cloſe to one another, as they appear on their back parts.

a b The manner in which the cells of one ſide are laid out, ſo as to form every three of them, by the union of their three baſes, 1 2 3, a hollow, which ſerves as a foundation for a cell on the oppoſite ſide. For this reaſon, if you run pins through the three parts of 1 2 3 of the bottom of one cell, one pin through each part, every pin will penetrate into a different cell of the oppoſite ſide. And on the other hand, on running pins through the bottoms of three contiguous cells of the oppoſite ſide, in that part where the ſaid bottoms lie neareſt to each other, theſe pins will all meet in one cell.

FIG. IX. Letter *b*

The cell of a female Bee repreſented by itſelf, to exhibit the more diſtinctly its pear-ſhape form, narrow mouth, ſpacious bottom, its length, and the unevenneſs of its external ſurface.

FIG. X.

A building, conſiſting of nineteen cells, eighteen of which contain the rudiments of Bees. Nine of theſe eighteen cells have got in them eggs, placed on their ends, and four others contain young worms, that have but lately ſhed their ſkins; the five remaining cells contain Worms a little bigger, and better grown. Of theſe laſt, that marked with letter a *is the largeſt,*

FIG.

FIG. XI. Letter *a*.

Six eggs drawn after nature, and placed on their ends. Theſe eggs are oblong, very ſlender, but ſomewhat thicker on their upper parts.

FIG. XII. Letter b.

Another Bee's egg viewed with a microſcope. It reſembles the ſkin of a fiſh, diveſted of its ſcales, but ſtill retaining the marks of their inſertions.

FIG. XIII.

Worms of Bees of different ſizes, drawn after nature.

a A Worm newly hatched.
b c d e Four worms that received more nouriſhment, and are more grown.
f g Two worms ſtill bigger than the former, having had more time to make uſe of the nouriſhment provided for them. They are here repreſented, as they lie doubled in their cells.
h A Worm placed on its belly, ſo as to ſhew on its back a black line, inclining to a light blue or gray. This line denotes the ſtomach, which appears in this place through the tranſparent parts that lie over it.
i A Worm lying on its back, and beginning to draw in the hinder part of its body, and move its head.

FIG. XIV.

The full grown Worm of the Bee, viewed with the microſcope.

a a a Its fourteen annular inciſions or diviſions.
b The head. *c c* The eyes. *d* The lip.
e e Two ſmall parts, which afterwards form the antennæ or horns.
f f Two other ſmall, and as it were, articulated parts, which form the teeth.
g The rudiment of the tongue or proboſis.
h h h Ten breathing holes.
i The ſtomach appearing on the back through the parts encloſing it.

FIG. XV. Letter *a*.

The little houſe or neſt of a Hornet, compoſed of bits of barks.

FIG. XVI.

A Bees cell full of Bees bread, placed in layers.

b Little grains, of which the ſaid ſubſtance, viewed with the microſcope, appears to conſiſt.

TAB. XXIV.

FIG. I. II. and III.

Exhibiting the manner in which the pulmonary tubes, and breathing-holes of a Bee's worm, are conſtructed.

a a a 1 2 3 4 5 6 7 8 9 10 Ten pulmonary tubes, open on each ſide.
b b Tubes which reach in circumference from one breathing-hole to another, by which means there is a communication between all the holes.
c c The anaſtomoſis, or inoſculation of the pulmonary tubes belonging to the oppoſite ſides of the body.
d d d The breathing-holes, or orifices of the pulmonary tubes. Theſe holes lie naturally under the ſkin, though they are here repreſented, as if they projected beyond it.
e f Rings compoſing the pulmonary tubes. Some of theſe rings *e* are longer than others *f*.
g g The ſkin cut off.

FIG. IV.

The manner of finding out the blood-veſſels of Inſects.

a A glaſs tube, part of which bellies out in the middle.
b One of its ends drawn out to a very ſharp point.
c The other end, which is more open and wide than the former. It is at this end that the air is blown in.

FIG. V.

The tubes that prepare both the matter of which the Worm forms its thread, and help it to form them.

a The tubes themſelves in which the ſaid matter is prepared.
b The place where theſe tubes meet, and form one trunk.
c c The diviſions of the tubes.
d d d d The ends of the tubes, broken off.

FIG. VI.

Some of the viſcera of the Worm of a Bee.

a a The ſtomach.
b The oeſephagus or gullet.
c Glands appearing through the coats of the ſtomach.
d d Pulmonary tubes cut off from each ſide of the ſtomach, over which they ſpread an infinite number of ramifications.
e The tranſparent muſcles of the ſtomach.
f The pylorus.
g g g g Four blind veſſels or guts.

h h The

h h The infertion of thefe veffels under the pylorus.
i The other guts, or inteftines, the thick and the ftraight.
k The extremity of the ftraight gut, with the fkin ftill adhering to it.
l The internal coat of the ftomach, full of a cogulated mattter.

FIG. VII.

The web which the Worm of the Bee forms, and in which it afterwards enclofes itfelf.

a The lower part of this web. This part is of a membranaceous fubftance, pretty thick, and ends in a triangular point.
b The enclofed Nymph of the Bee, tranfparent in the middle.
c The upper part of the web. This part is convex, and the threads compofing it are very difcernible.

TAB. XXV.

FIG. I.

The Worm of the Bee, forming its web.

a a The fides of the cell that contain it.
b The bottom of the cell.
c The entrance or door of the cell. The Worm is here reprefented as making its web in the propereft manner to fhut up this entrance.

FIG. II.

The Worm of the Bee taken out of the web, in which it had enclofed itfelf, and juft ready to caft its fkin.

a The Worm of the Bee quite deftitute of motion, after it has finifhed its web, with which it is entirely furrounded.
1 2 3 The three annular incifions, or divifions next its head; the fecond and third of which begin to be confiderably diftended, by the limbs growing under them.

FIG. III.

A cell, containing the Worm of the Bee changed into a Nymph, and perfectly lined with the faid Worm's web. Likewife the faid web entire, with the Nymph contained in it, as they appear on opening the cell.

a a The fides of the cell, lined with the Worm's web.
b The mouth of the cell, perfectly clofed by the web.
c The bottom of the cell.
d The web. entire, as it appears on opening the cell, which it greatly refembles in form.
e The upper part of the web, of a convex form. This part fhews its filaments pretty diftinctly.
f The enclofed Nymph appearing through the tranfparent fides of the web.
g The bottom of the web, anfwering to that of the wax-cell.

FIG. IV.

The Worm of the Bee, on the point of changing to to a Nymph, and ftripped of its fkin, the better to fhew the infant parts of the future Bee, which are here reprefented as they appear through the microfcope, after extending them a little.

a a The antennæ, or horns.
b The probofcis, with its parts.
c c The fecond pair of joints belonging to, or forming, the probofcis.
d d The firft pair.
e e The firft pair of legs, lying againft the breaft.
f f The fecond pair of legs.
g g The third pair.
h h The greater wings.
i i The fmaller wings.
k The abdominal wings.

FIG. V. and VI.

The Worm of the working Bee, changed to a Nymph, of its natural fize and form, yet fo as to exhibit its limbs, which are folded up in a moft wonderful manner.

a a The head.
b b The greater eyes, one at each fide of the head.
c c The antenna, or horns. *d* The probofcis.
e e The wings. *f* The three pair of legs.
g The abdominal wings.

FIG. VII.

The Worm of a Female Bee, changed into a Nymph, fhewing its parts difpofed in the fame manner with the former.

FIG. VIII.

The Worm of a Male Bee, changed into a Nymph, differing externally from the two former Nymphs no otherwife than as the Male Bee itfelf differs from the Female Bee, and the working Bee.

FIG. IX.

The Nymph of the Bee viewed with the microfcope, difplaying in a diftinct manner all the parts of the enclofed infect, and the beautiful manner in which they are laid up.

a The head, bloated with humours.
b b The eyes, projecting confiderably.
c c The horns, or antennæ.
d The lip. *e e* The teeth, or jaw-bones.
f f The firft pair of joints belonging to the probofcis.

g g The

g g The next pair. *h* The probofcis itfelf.
i i The firft pair of legs.
k k Two tranfparent, ftiff little parts, lying againft the loweft joints of the firft pair of legs. Thefe little parts are not to be found as they remain in the fkin it fheds on quitting the Nymph ftate.
l l The fecond pair of legs.
m m The wings. *n n* The blade bones.
o o The laft pair of legs.
p p The abdominal rings.
q The hinder parts of the body. The fting projects a little in this place.
r Two little parts accompanying the fting.
s The anus.

FIG. X.

The diftribution of the pulmonary tubes through the wings, as they appear through the microfcope.

a The origin of the wings, where the pulmonary tubes are biggeft.
b Ramifications and mutual anaftomofes or inofculations of the faid tubes through the wing.
c The extremities of the faid tubes.

TAB. XXVI.

FIG. I.

The nefts or habitation of the Humble Bees.

a One part of the neft, containing eighteen cells. *b* Another part, containing eight cells.
c A cell quite empty, and open.
d An irregular bit of wax placed againft one of the cells, in which I found fix eggs.
e An irregular bit of wax placed againft one of the cells, in which I found twenty-three eggs.
g A part of the little cells that contained worms.
h A little Worm extracted from its cell, juft as it was on the point of becoming a nymph.
i A large Worm of that kind, of which I found two in a cell that was fhut up.
k A larger Worm, found by itfelf in one of the cells.
l A cell divided into two parts, in one of which I found two fmaller Worms, and in the other two, a little bigger.
m A little worm of that kind, of which I found three in one cell.
n A little Worm of that kind, of which I found four in one cell.
o The eggs of thefe infects faftened or glewed by one of their ends, to the furface againft which the parent lays them.

FIG. II.

Exhibiting the Lupus Alvearius, or Beehive Wolf, and the particulars of its hiftory.

a The Vermicle, or Worm called the Beehive Wolf, by thofe who feed them.
b A Butterfly of a pale gray, refembling a moth, from which the Beehive Worm iffues; after which it lays amongft the honey-combs.
c c A hollow tubulated web, which the Worm Lupus, or Beehive Wolf, forms, and in which it runs about here and there, as in fo many burrows.
d A fmaller Butterfly, producing a fmaller kind of Beehive Wolf.
e The web, which on the outfide appears rough and uneven with the Infect's or Worm's excrements, and contains the Beehive Wolf-Worm, now full grown, and on the point of performing its mutation.
f The Chryfalis or Aurelia, into which the Beehive Wolf Worm is changed.

FIG. III.

The little Worm found in the Nefts of Wild Bees, and its mutations.

a The Worm itfelf. with fix feet, and of a reddifh colour.
b The Nymph, into which the faid Worm afterwards changes.
c A beautiful Beetle, which, within the fpace of a year, iffues from the faid Nymph, fo as to make it plainly appear that neither the Nymph nor the Worm belonged to the tribe of Bees.

FIG. IV.

Another fpecies of Wild Bees, reprefented a little bigger than nature.

FIG. V.

A third fpecies of Wild Bee.

FIG. VI.

A fourth fpecies of Wild Bee, having very long and very thick antennæ or horns.

FIG. VII.

A fifth fpecies of Wild Bee.

FIG. VIII.

A fixth fpecies of Wild Bee.

FIG. IX.

A Hornet.

a a The Infect's four wings.
b b The two fharp nails with which the extremity of each leg is armed.
c The head, with its eyes in the form of a crefcent, horns, probofcis, and teeth.
d Its formidable fting.

FIG. X.

A Wafp of a middling fize.

FIG. XI.

A Waſp of an unuſual form.

FIG. XII.

An Humble Bee of a middle ſize, having its belly ſurrounded with hairs of different colours.

FIG. XIII.

A tripilis Muſca, or three-haired Fly, being a kind of Pſeudophica.

FIG. XIV.

The Neſt of the ſmalleſt ſpecies of Waſps.

c c c Three integuments, or coats of the neſt.
d The body of the neſt, of which a piece is broken off, to ſhew the
e The hexogonal cells in which the eggs are hatched.

FIG. XV.

A Waſp's neſt, that I found ſticking to a nettle, compoſed of nothing but cells, built cloſe one againſt another, without any integument, or common covering.

TAB. XXVII

Repreſenting the hiſtory of the Naſicornis, or horned Beetle

FIG. I.

The Male.

a Its horn, which, properly ſpeaking, grows rather from the head than the noſe.
b Its mouth, ſeated in the breaſt, furniſhed on the upper part with three little teeth, of a ſubſtance between bone and horn, and without any perioſteum; theſe creatures differ from men and quadrupedes in this, that their bones do not lie hid within their bodies, but appear naked on the outſide of their fleſh, to which they ſerve as a defence and covering.
c The ſhells or ſheaths of the wings.
d A little triangular, horny bone, placed between the ſaid ſheaths, which it ſerves to keep cloſe to the body, and in the proper ſituation: this bone lies on the firſt ring of the abdomen.
e The edge or border of the ſheath, forming a kind of ornament.
f One of this Hornet's eyes.
g g Two antennæ or horns: thoſe of the male are bigger than thoſe of the female.
h A little horny bone, forming the third joint of one of the Hornet's ſix legs, which are all of them covered with coarſe hairs.
i The foot itſelf, conſiſting of five joints, the laſt of which is armed with two crooked nails.

FIG. II.

The female, ſcarce differing from the male in any thing but ſize, and her not having a horn.

a A ſmall prickle growing on the female's head, to ſupply as it were the want of a horn.
b The wings expanded under the ſheaths, and the ſheaths themſelves a little drawn in, by which means a better view is obtained of the little triangular bone, which ſerves to retain the ſheaths in their proper ſituation. Between theſe ſheaths there appear on the upper part of the fore or firſt rings of the abdomen, which in the male can only be ſeen in the lower part under the ſheaths.
c c Two joints in the rings themſelves, which they ſerve to fold, ſo as to make them fit under their ſheaths, that they may receive no harm, while the Hornet creeps under ground.

FIG. III.

The Eggs.

a Two larger eggs.
b Two ſmaller eggs, but of different ſizes.

FIG. IV.

The Worm.

a The Worm of the horned Beetle, called Coſſus, newly hatched. It here exhibits its very large head, two teeth, and three legs belonging to one ſide of the body.

FIG. V.

The Coſſus full grown,

a Beautiful wrinkles and folds, with which the ſkin is adorned.
b Nine reddiſh ſpots on one ſide of the body, having each of them a hole through which the Worm breathes, and ſupplies with air its pulmonary tubes.
c A ſpot like the former, belonging to the other ſide of the body, and placed on the firſt or ſecond ring of it
d One of the horns, which conſiſt each of five joints.
e e The teeth, or jaw bones.
f Two articulated briſtles, above which the lip appear ſeated between the teeth.
g Three of the inſect's ſix legs, each of which is compoſed of five joints, formed of a ſubſtance between bone and horn, beſides a ſingle nail; and which are moreover covered with hair.
h Some pulmonary tubes which appear through the extended out-ſkin of the thirteenth and fourteenth rings of the inſect's body.
i The extremity of the ſtraight gut forming the anus.

k k Hairs

k k Hairs covering the body. I here reprefent but thofe that grow on the back and abdomen, to avoid the neceffity of making the figure bigger than nature.

FIG. VI.

The exuviæ, or caft fkins, and pulmonary tubes caft off by the Coffus.

a a a Nine twifted little threads of the pulmonary tubes, appearing in one fide of the caft fkin, rolled off from the body through the breathing holes, at the time the Worm undergoes this mutation; accordingly all their extremities lie in a direction towards the fore end of the body, as the fkin at this time falls off in a contrary direction from the hinder end.

b b Two fmaller branches of the pulmonary tubes, one at each fide of the body. Tho' thefe branches do not perforate or pafs thro' the fkin, neverthelefs as they are faftened to it, they come away at the fame time. One of thefe branches is divided into fome ftill fmaller ramifications; the other appears exactly in the condition, in which with the other nine it fell naturally from the body.

c c c c Some branches and fmaller ramifications of the nine pulmonary tubes of the other fide, a little folded out.

1 2 3 The fkull, which at this time divides into three parts.

d d The caft teeth, which are hollow.

e The caft lip.

f f The horns, which are likewife renewed.

g g The two other remaining parts of the parted fkull. They are hollow, and of a fomewhat fpherical form.

h Six openings in the fkin, that formerly contained the new legs.

i The hinder part of the fkin folded up.

FIG. VII.

The fibres ferving to move the rings.

FIG. VIII.

The heart of the Coffus.

a The heart refembling a membranaceous tube.

b The narroweft part of the heart, feated near the head.

c Two dilatations of the heart.

d That part of the heart, which lies within the laft rings of the body, and is very flender.

FIG. IX.

The fat, compofed of globules, like the grains of fand.

FIG. X.

The fat examined by the Microfcope,

a a The tranfparent membranaceous foundation of the fat cell.

b b Some pulmonary tubes diftributed through the fat.

c c Globular and oily particles of fat, which float, as it were, in other membranaceous, globular, and irregular particles, fo as to make it probable that this fat confifts of bladders.

FIG. XI. and XII.

The ftomach, and adjacent parts.

a a a a The diffected fkin of the Coffus.

b The gullet. *c* The upper part of the ftomach.

d d Appendages of the ftomach, in the fhape of teeth, feated about the upper end of the ftomach, and divided both above and below, into rows.

1 2 The two upper rows in their natural fituation. *Fig.* XII. *e.* All the fix upper rows of the appendages, as well thofe belonging to the upper, as thofe belonging to the lower region are here exhibited, but as they appear when taken out of the body.

1 2 Two of the rows already exhibited, in an inverted fituation, as they naturally lie with their points directed towards the infect's head.

3 4 Two lower rows in the fame direction.

5 6 The two laft rows of the appendages, adhering to the lower region of the ftomach, with their points directed backwards.

f A future on the lower furface of the ftomach, in fome meafure refembling that of the peritonæum.

g Some other appendages of the ftomach, lying lower down than thofe already taken notice of, with their points directed backwards.

h The hinder part of the ftomach.

i i The loweft appendages, which appear as it were in the bottom of the ftomach. Thefe appendages are directed towards the head.

k k k k The vafa varicofa, or the fwollen guts of the ftomach, placed on the upper and lower parts of it, and on each fide, and forming a moft beautiful appearance.

l The pylorus with the flender gut, which fprings from the ftomach. This part the antients call Ecphyfis.

m The colon.

n n Pulmonary tubes running from the laft pair of breathing holes towards the ftomach, and branching into a great many ramifications, that are diftributed over the ftomach, the colon, and the ftraight gut.

o o o o The other fixteen breathing holes, in their natural fituation, as they appear thro' the fkin.

p The ftraight gut, difplaced.

q A rough draught of the parts of the head.

TAB. XXVIII.

TAB. XXVIII.

FIG. I.

The brain and ſpinal marrow of the Coſſus.

a The brain, with the four nerves that it produces.
b Two origins of the ſpinal marrow at ſome diſtance aſunder, but meeting lower to form one trunk.
d d d Nerves iſſuing from the ſpinal marrow.

FIG. II.

A recurrent nerve, as is appears through the microſcope.

a a The origins of the recurrent nerves, cut off in that place where they iſſue from the brain.
b b Recurring nerves, tending upwards; their aſcent may be ſeen on each ſide of the inſect's gullet.
c c Elegant inflections of the recurrent nerves.
d The firſt nodule formed by the recurrent nerves after their union.
e A recurrent nerve again changed to a ſingle one.
f The ſecond nodule of a a recurrent nerve.
g Small nerves branching from a recurrent nerve.

FIG. III.

The ſpinal marrow of a Silk-Worm when about to enter the Nymph ſtate, the better to ſhew the difference between its ſpinal marrow and that of the Coſſus. As likewiſe what little reaſon ſome people have to conſider every dilatation of the marrow as a diſtinct brain.

a The brain.
b b b 1 2 3, &c. The ſpinal marrow, conſiſting of twelve globules or nodules, which are formed as it were by the union of twelve pair of nerves iſſuing from the brain.
c c A pair of nerves running to the eyes.
d d A conſiderable part of nerves iſſuing from the firſt nodule of the marrow, and tending towards the muſcles of the head, teeth, and other parts. Every one of theſe nerves form by itſelf a beautiful nodule.
e e Two of theſe nodules.
f A pair of very fine nerves iſſuing from the brain, or origin of the ſpinal marrow.
g The recurrent nerves in their natural ſituation, with the two nodules belonging to them, and the nerves ariſing from the ſaid nodules.
h A pair of nerves ariſing from the firſt nodule of the marrow, and running towards the little bags that contain the juice of which the ſilk is compoſed, like a glutinous liquid. This pair of nerves ſerves perhaps to animate the moving and extruding fibres of the ſaid ſilk bags.
i i Two pair of elegant nodules, formed by nerves that proceed from the brain, and firſt nodule of the ſpinal marrow, and are diſtributed chiefly towards the muſcle of the head.
k k k k Four pair of nerves which iſſue from the very origins of the marrow, and by no means from its nodules. In my opinion the origin of all the other nerves is like this, as more particularly appears in the nerves of the Silk-Worm Butterfly, in which the ſubſtance forming the nodule is of a different nature from that of the ſpinal marrow, ſo that the whole is encloſed in the latter merely for the ſake of procuring it greater firmneſs.

In man, the origin of whoſe marrow conſiſts likewiſe of two parts, the nerves ariſe in like manner from the nervous part of the marrow, which is full of fibres, and after proceeding a little way beyond the ſaid nervous part, and growing ſomewhat longer, they every one of them unite to form ſuch nodules at different diſtances from their origin. The ſame diſpoſition is obſervable even in quadrupedes. On placing the warm marrow of theſe inſects on cold ſpring water, it hardens to a conſiderable degree, and very plainly exhibits its fibres, and the heterogeneous matter, of which it is formed. This circumſtance I have repreſented by a great many curious drawings, done after nature, in Dr. Slade's houſe, from a ſpinal marrow, publiſhed by Dr. Blaſius with his book of Commelyn. But this laſt gentleman added the deſcription. My name was not mentioned on this occaſion, becauſe ſome other Gentlemen, who aſſiſted me in the diſſection, not chooſing to have their names made publick, I thought it improper that mine ſhould.

It is likewiſe very remarkable, that in men and brutes, the pia mater, encloſing the medullary ſubſtance that iſſues like a fine filament from the marrow, in order to form a nerve, lies ſo cloſe and firm about the nerves, that it is ſcarce, if at all poſſible, to penetrate into its ramifications with the fineſt threads that glaſs can be drawn into. And as this narowneſs is ſtill increaſed by the medullary ſubſtance, it is eaſy to gueſs how ſubtile that matter muſt be, which flows through theſe and other nerves, and is only reſtrained by that very fine membrane called the pia mater, I therefore firmly believe, that this matter, called the animal ſpirits, is not to be gathered or contained by any veſſels, and is, for that reaſon, altogether inviſible.

But that theſe little nerves ſhould be in no danger of entangling one with another, or diſplaced, the Author of Nature has contrived that they ſhould form various nodules; and that each of them, at its origin, ſhould, in men, as well as beaſts, be connected by that delicate membrane, which forms the third coat of the brain, and is called, by us, arach-

Arachnorides, on account of its extreme finenefs. The cavities of the ventricles of the brain are united together merely by means of the faid coat, which likewife ferves to keep firm in their proper fituation the arteries adhering to the bottom of the brain. As therefore the ventricles of the brain have no other coat to enclofe and connect them, but this very delicate one, which gives way to the flighteft impreffions, we may eafily fee, that the faid ventricles are by no means fuited to contain the animal fpirits, which no doubt are continually paffing and repaffing through the whole fubftance of the brain, marrow, and nerves, in order to contract the mufcles. It is therefore the pia mater alone that can be fuppofed to contain the animal fpirits. But I abfolutely deny, that, as fome people think, thefe fpirits pafs in great quantities through the faid coat, as there are not to be found in the brain or origin of the marrow any ventricles ; or any great quantity of fpirits, that we may fuppofe to be driven backwards and forwards in fuch a manner. Befides what power fhould drive them. There are no mufcles at hand for that purpofe ; and as to the opinion of fome, who attribute fuch a motion to the heart, experience fufficiently proves, that the juices fecreted from the blood move flower than the blood itfelf. It would be more agreeable to experience to fuppofe, that fome juices are fecreted from the blood into the nerves, in order to move the mufcles; nor would a great quantity of fuch juices be neceffary, as appears plainly in the cafe of the fmalleft tumours.

In Frogs, the Wray-fifh, and other animals, after the nerves have been feparated fome hours from the fpinal marrow, and all motion has ceafed in the mufcles, I can notwithftanding reftore the faid motion, by only any how irritating the nerves fo cut off. And this makes me believe, that the blood, that continually flows through the arteries into the marrow and nerves, produces in the mufcles, by means of the nerves, fuch a conftant irritation, as muft keep the mufcles in a ftate of perpetual contraction. To explain the mechanifm of this motion ; The food we take in, after paffing through the heart, increafes our blood : the blood drives to the brain, irritates the mufcles to contraction, by fecreting fome few fubtile particles, which are moved towards the nerves, and penetrate them. The mufcles will, in their turn, put their contents in motion, and thus a perpetual and uninterrupted motion muft of courfe be produced in all the parts of the animal machine. It would certainly be worth while to demonftrate, by a due courfe of experiments, thefe operations of the blood, fpirits, nerves, and mufcles. What I have here faid of them is only by way of parenthefis, and therefore I think I have faid enough.

l l l l Some very beautiful inofculations of the nerves.

m m m The reft of the nerves iffuing from the lower part of the medullary nodules.

n n n &c. Some parts of the fpinal marrow, where its divifions are not fo confpicious, as more particularly appears in three places near the breathing-hole, or refpiratory points.

1 2 3, *&c.* Nine breathing-holes, which I here reprefented, to fhew the fituation of the fpinal marrow, with refpect to the annular incifures of the body.

o In this place I have reprefented the fpinal marrow with a greater cleft, than it really has, the better to fhew the nerves *l l*.

The remaining part of this figure reprefents the genital parts of the Male Silk-Worm Butterfly.

p p Two branches of the laft and greateft pair of nerves, which branches, proceeding from the loweft part of the marrow, are cleft near their extremities, and form a flit for the paffage of the vafa differentia *r r*.

q q The tefticles of the Silk-Worm Butterfly, already difcernible in the Silk-Worm itfelf.

r r The vafa differentia.

s s Places at which the faid veffels run in a furprifing manner through the nerves of the marrow. I leave others to judge whether or no this difpofition contributes to increafe the titallation.

t A proftata, or fomething analagus to that glandule.

u u The faid bags, fupplied with their feminal matter from two diftinct tubes. Thefe bags are not only feparated from the vafa differentia, but have not the leaft communication with them.

x x The body of the penis, with a perforation from end to end for the paffage of the feed.

y y Two nails or hooks growing near that part of the penis, which is of a fubftance between bone and horn. It is by means of thefe nails or hooks that the male fixes itfelf againft the vulva of the female, and draws her towards him, the furer to penetrate her with his penis. The fame contrivance appears in the horned Beetle, and other infects.

z Part of the penis, confifting of a horny bone. The bone ferves as a præputium or fheath, from whofe fore end the penis projects.

FIG. IV.

An oval neft, hollowed out under ground by the Coffus, in which it changes to a Nymph.

a a The earth in which the Coffus had formed its oval neft.

b The neſt itſelf.
c The Coſſus, changed into a Nymph.

FIG. V.

The changes viſible in the internal parts of the Coſſus, a little before its entering the nymph ſtate.

a The gullet as not yet altered, and paſſing through a cleft in the marrow, while the Coſſus continues in the Worm ſtate.
b b The ſtomach, with its appendages conſiderably contracted.
d d d The vaſa varicoſa ſeparated from the upper and lower parts of the ſtomach, and out of their natural ſituation.
e The inſertion of theſe veſſels; for behind the pylorus they open by four tubes into an ecphyſis.
f f The colon, almoſt of its former ſize, owing to the contents of the ſtomach and ſmall gut being fallen into it.
g Cells of the colon, with its ligament in the middle.
h The ſtraight gut.
i i The vaſa varicoſa folded and coiled in a moſt ſurpriſing and beautiful manner againſt each ſide of the ſtraight gut.
k A rough draft of the Worm's head.

FIG. VI. VII. and VIII.

A front view of the Nymph of the Coſſus, and all its parts, ſlightly expreſſed by the graver, and deſcribed by lines only, the better to ſhew its parts. The eighth figure repreſents the lower parts of the Coſſus's head, that the changes it undergoes may be the better comprehended.

a The horn growing on the noſe.
b The root of the ſaid horn; which in the Beetle is covered on its lower part with ſome ſtiff red hairs. This part grows in the noſe of the Coſſus.
c c Two ſpherical tubercles, being the remains of the Coſſus's teeth *d d.* Fig. VIII. And therefore theſe teeth are four times ſmaller in the Beetle, than they were in the Coſſus.
d d The teeth of the Coſſus.
e e Two pair of tubercles like the former, being the remains of the Coſſus's horns *f f* Theſe tubercles are of quite another form in the Beetle.
f f The Coſſus's two horns.
g g Two tubercles of a more oval form, grown from the articulated briſtles of the Coſſus *h h,* and afterwards viſible in the Beetle itſelf.
h h The articulated briſtles of the Coſſus.
i Three beautiful globules placed in the middle, and growing from the particles of the Coſſus marked *k.* Theſe globules are likewiſe of another figure in the Beetle.
k The four briſtles of the Coſſus, already taken notice of.

l The greateſt ſpherical diviſion of the Nymph, which in the Beetle conſiſts of a horny bone, and is covered with hair on each ſide.
m m The breaſt bone.
1 1 The firſt pair of legs.
2 2 The ſecond pair.
3 3 The third pair, with its joints
n n The ſheaths of the wings.
o o A ſmall portion of the wings themſelves.
p p The abdominal rings.
q The two ſhield-like parts of the anus.

FIG. IX.

A back view of the Coſſus, ſhewing the fourteen annular inciſions of its body, and the tranſpoſition of its breathing-holes.

1 The firſt ring of the body, now armed with a horn on the head.
2 1 The ſecond ring, in which the firſt pair of breathing-holes is ſeated under the fore legs, one at each ſide of the thorax.
3 4 The third and fourth ring, which form but one ring, and may be ſaid to conſtitute the hinder part of the thorax.
5 2 The fifth ring, in which the ſecond pair of breathing-holes is ſeated under the wings, one at each ſide.
6 3 The ſixth ring, in which the third pair of breathing-holes externally appears, one at a ſide, on the borders of the belly.
7 4 The ſeventh ring, and fourth breathing-hole.
8 5 The eighth ring, and fifth breathing-hole.
9 6 and 10 7 } The ninth and tenth ring, and ſixth and ſeventh breathing-holes, all very diſtinct in the Coſſus, but in the Beetle pretty cloſely united.
10 8, 12 9, 13 } The eleventh, twelfth, and thirteenth rings, which now in a manner form but one ring. The eighth pair of breathing-holes, placed on the eleventh ring, is almoſt cloſed up in the Nymph. And the ninth pair, which in the Coſſus appeared in the twelfth ring, is no longer to be ſeen in its Nymph.
14 The fourteenth ring, viſible only in the belly, between the two ſhield-like parts. I here only mark its ſituation.

TAB. XXIX.

FIG. I.

The Caterpillar of the ſwift Butterfly.

a Its head, and ſome of the hairs growing on its forehead or forepart; likewiſe its two teeth.
b Its breaſt. *c* Its belly.
d Its tail, in which are ſeen its two hinder legs.
e The extremity of the tail, ending in a point. Neither the breathing-holes, the fore, or middle part, are to be ſeen in this Caterpillar,

pillar, as I have reprefented it lying on its belly.

FIG. II.

The Chryfalis or Aurelia of the fwift Butterfly, belonging to the fecond mode of the third order or clafs.

a The eye.
b The probofcis, beautifully bent back towards the belly.
c The horns and legs, ftretched over the body.
d The wing belonging to one fide.
e e The rings of the breaft, and of the abdomen.

FIG. III.

The fwift Butterfly.

a a The eyes.
b b The antennæ or horns, growing above the eyes.
c The probofcis, confifting of a double tube, by means of which this infect conftantly fips up its food, while flying. It is to be noted that the great length of this curious organ is contrived by Nature, that the infect fhould take its food without being obliged to fly too near the flowers, which might injure its wings.
d The extremity of the probofcis, coiled up by means of fome minute mufcles. Thus the Butterfly can gather up this part into a little compafs, and hide it between the forks.
e A fide view of part of the forks. The forks are two particles covered with hairs, formed like a feather.
f The tail, by means of which the infect, when on the wing, fhapes its courfe; fo that its flight is fteddier than that of other Butterflies. The reft appears behind the head and breaft, and the abdomen, which is beautifully adorned with hairs, made in form of feathers, and of changeable colours.
g g The upper wings, which are the largeft.
h h The lower wings. All the four wings are curioufly ornamented with hairs and fcales. And thefe ornaments, by containing a great deal of air, make the Butterfly lighter than it otherwife would be, and confequently the fitter for flying.

FIG. IV.

The Sicarius, or Affaffin Worm, an aquatic infect.

a a Its fix hairy feet.
b. Its hairy tail, furnifhed, as it were with two oars, by means of which the Worm can float on the furface of the water.
c c Sharp and crooked teeth with which this infect kills other infects for its food, and fucks up their blood.
d d Eight of the infects twelve eyes, of which fix are at one fide of the head, and fix at the other.
e e e Four ariculated briftles growing under, and between the teeth.
f f Two longer briftles, which may be confidered as the infects horns.
g Six breathing holes. This Worm has fixteen.

FIG. V.

A tooth of the Sicarius, or Affaffin Worm, viewed with the microfcope.

a The point of the tooth, fharp, and crooked.
b A fharp ridge on the internal furface of the the tooth.
c The convexity of the external furface.
d An oblong aperture, or flit, through which that infect fucks its food.

FIG. VI.

The breathing holes of the Beetle, in their natural fituation; as likewife the rings of the body, which may be taken from the figure of the Nymph already exhibited.

a 1 The firft breathing hole placed obliquely backwards in the breaft bone, upon the fecond ring.
b 2 The fecond breathing hole, fituated higher under the wings in the fifth ring, and in an oblique direction to the firft breathing hole.
c 3 The third hole, fituated a little higher up on the edge of the abdomen, and in the fixth ring,
d 4 The fourth ftill a little higher up on the feventh ring.
e 5 The fifth higher up again in the eighth ring.
f 6 *g* 7 *h* 8 The fixth, feventh, and eighth holes, confiderably fmaller than the preceeding ones. They lie on the ninth, tenth, and eleventh rings.
i 9 The ninth hole, that appeared in the twelfth ring, now quite clofed up.

FIG. VII. and VIII.

The eyes, optic nerves, and brain of the Beetle.

a The eye juft diverted of the cornea, and the uvea, fo as to fhew its inverted pyramidal fibres.
b A fnow white fibrous coat of the eye, in which all the pyramidal fibres terminate.
c The optic nerve feparated from the infide of the faid coat's cavity.
d The dark colour of the faid coat. There are in this place a great many ramifications of the pulmonary tubes, of which I have reprefented three branches.
e The manner in which the pulmonary tubes run along the inverted pyramidal fibres in a a ferpentine courfe towards the cornea, in the eye of a live Beetle. I have reprefented thefe pulmonary piftules, fomewhat thicker than

than they really are, that they may appear the more diſtinct.

f f Two horny bones growing on the ſkull, over the eye, which they in a manner divide.

g An expanſion of the ſkull, of a ſubſtance between bone and horn, commonly called the noſe-horn, with its rugged ſurface.

h A ſuperficial diviſion of that part of the eye, which lies within the ſkull; this diviſion is formed by the upper projections of the ſkull.

i The brain, conſiſting, as it were, of two united globules.

k Pulmonary tubes of the dura mater, and optic nerves.

l l The fineſt parts of the optic nerves, juſt at their iſſuing from the brain.

m m The ſame nerves grown bigger.

n n The ſame grown ſmaller.

o o The ſame again increaſed, on their approaching the eyes.

p p The origin of the ſpinal marrow, cut off in that part where it forms a ſlit for the paſſage of the gullet.

FIG. IX.

The Pulmonary tubes, with their veſicles in the horned Beetle.

a a Diſtended veſicles of the pulmonary tubes, of which I here give an entire branch bigger than nature.

b b Tubes and their literal branches, ſpringing from the upper part of the veſicles.

c c Some tubes iſſuing from the ſides of the ſaid veſicles.

FIG. X.

A pulmonary branch and its veſicle, viewed with the microſcope.

a a Rings that compoſe the tube, of a ſubſtance between bone and horn.

b The ſtructure of theſe rings, which is ſuch as to make it probable they are formed by a concretion of ſpherical particles.

c c Some places, in which the convolutions, compoſing the rings are terminated, and ſucceeded by new ones.

d d Membranes binding the rings together; in theſe membranes there appear ſpherical particles, of which they are in a manner compoſed.

e e Some ſmaller rings at the top and bottom, of the pulmonary veſicle.

f f The ſtructure of the pulmonary veſicle itſelf. It is of a white membranaceous ſubſtance, compoſed of an infinite number of minute globules, which on account of their convex ſurfaces give this part, as often as the light ſhines on it, a white colour, though without any reſplendency.

TAB. XXX.

FIG. I.

Viſiculæ pneumaticæ, or breathing, or pulmonary veſicles, that appear between the two plates of the ſheath covering the wings.

a a The two largeſt branches of the trachea, which appear through the ſaid plates, on holding them to the light, and examining them with the microſcope in that ſituation.

b b b Pulmonary tubes iſſuing from the branches *a a*, with their veſicles.

c c c Pulmonary tubes iſſuing from the ſaid veſicles, and again forming other veſicles and tubes, *&c.*

FIG. II.

The firſt ſpecies of an Exotick, Rhinoceros, or horned Beetle.

a Its eye, from which iſſue the projecting part of the ſkull.

b An excreſcence of the ſkull, forming a kind of horn, in the middle of which there appears a tubercle with a ſharp point, and a ſingle cleft at its end.

c The breaſt bone projecting on the fore part in a ſingle tube, which terminates in two teeth.

d d The two lids or covers of the wings, between which there lies on the inſect's back about its breaſt a triangular horny bone. This bone keeps the lids or covers when ſhut from running one over the other.

e The abdominal rings, in which are the two breathing holes of the Beetle, that are almoſt cloſed up; I have left them unſhaded, that they may appear the plainer.

f f f The three legs belonging to one ſide, with their joints, nails, and hair. The breaſt-bone of this inſect, and likewiſe the projecting part of the ſaid bone, and the noſe-horn, are all of a deep brown inclining to black; but the ſheaths of the wings are ſomewhat paler, and near to a light red. The legs are black.

FIG. III.

A ſecond ſpecies of the horned Beetle, which may be very properly called the flying Elephant.

a The eye belonging to one ſide of its head, in regard to which it plainly appears, that it is covered like that of the Dutch horned Beetle, by a projecting proceſſus of the ſkull, of a ſubſtance between bone and horn, and that it is likewiſe united with the ſaid proceſs.

b Another projection of the breaſt bone, of the ſame ſubſtance with that of the ſkull. This projection covers the eye too, but is by no means united with it; for the eye is only hid

hid by the ſaid projection, which ſerves as an eyelid, and moves backwards and forforwards over the eye, as the Beetle moves its head.

c Some ornaments of the ſkull.

d The noſe-horn of the ſkull, reſembling the proboſcis of an Elephant.

e A tubercle, in form of a tooth, growing near the end of the noſe-horn, which is moreover cleft in the middle; but as this is a ſide view of the inſect, the ſaid cleft cannot be ſeen.

f The breaſt bone.

g g Two ſharp prominent forks, or teeth of the breaſt-bone, in regard to which I conſider this inſect as having ſome reſemblance to an Elephant.

h The lids that cover the wings.

i The ſecond joint of the legs.

k The third joint.

l The fourth joint, or the foot, with its joints, hairs and nails.

As all theſe parts are compoſed of a ſolid horny bone, the muſcles are encloſed by them, whereas on the contrary in men and quadrupedes, the bones lie within the fleſh. This Beetle is very black, but ſhining withall, like poliſhed ebony, ſo as to afford a very pleaſing ſpectacle, eſpecially as its colour has a reddiſh caſt.

FIG. IV.

A third ſpecies of the horned Beetle.

a One of its eyes. *b* One of its horns.

c Its noſe-horn.

d d The breaſt-bone, and its projections.

e e The ſheaths of the wings. All the parts are gray, owing to an infinite number of ſmall hairs, that grow on them, the noſe-horn, and projections of the breaſt-bone excepted: But the ground of the horny bone, on which theſe hairs grow, is black, as is likewiſe the horny bone of the foot, whoſe hairs do not grow ſo cloſe, as thoſe covering the other parts.

FIG. V.

The breaſt-bone of a fourth ſpecies of Beetles.

a Some ornaments of this part, which is compoſed of a ſubſtance between horn and bone.

b A thick expanſion of the breaſt-bone.

c Its two blunt ends.

d Some hairs growing on the part that unites the head and thorax. Theſe hairs facilitate the motion of the head.

e Some projections of the ſkull.

f The noſe-horn, with its teeth.

g The horn, and one of the eyes.

FIG. VI.

A fifth ſpecies of a horned Beetle.

a Its eye.

b The noſe-horn, growing out of the ſkull, crooked and blunt.

c The firſt proceſſus of the breaſt-bone.

d The ſecond.

e The third. All theſe are only the limbs belonging to one ſide.

f A little prominent border, which is turned in, and entirely ſurrounds the breaſt-bone; it is found in every ſpecies of horned Beetles. Lower down, and more forward than the ſaid border, are to be ſeen thoſe ornaments of a horny bone, which are covered with looſe hairs.

g g A ſingle joint of the legs; the remaining parts may be conceived from the other figures.

FIG. VII.

Part of the heart of the Dutch horned Beetle.

a a Some broader parts of it.

b b Some narrower parts.

FIG. VIII. and IX.

The genital parts of the male horned Beetle.

a The part forming, as it were, the ſheath or foreſkin of the penis; this part is a horny bone.

b Two horny bones, or nails of the penis, by means of which the male, in copulation, fixes its penis into the vulva of the Female.

c The thick nervous part of the penis.

d The body or root of the penis.

e e The vaſa differentia, bigger in the middle than at the extremities.

f One of the teſticles quite unfolded, or laid open, in order to ſhew thoroughly the teſticulary veſſels.

g The extremity of the ſaid teſticulary veſſel. This veſſel is cloſed.

h The other teſticle, almoſt in its natural ſituation.

i The blind extremity of the teſticulary veſſel laid bare.

k k Seminal bags.

l l Two ſlender curled tubes, in which the ſaid bags terminate; and which terminate themſelves at each ſide into ſix other tubes.

m m Twelve moſt beautiful glands, ſix at a ſide, which are united with the ſaid twelve tubes, and ſend their ſeed to the penis by the ſeminal bags.

n The upper part of theſe glands, which is flattiſh.

o The lower part, which is globular.

p The lower ſide of the ſaid globular part, ſomewhat magnified, ſo as to ſhew in what what manner it is united with the tube of the

the feed-bag. This part contains a limpid feminal matter.

q A fubftance furrounding the feminal matter, which refembles the white of an egg.

FIG. X.

The ovary of a Female, and its parts.

a The head of the female, feparated from the body.

b The gullet and ftomach.

c The inteftines.

d The exitus, or extremity of the inteftines.

e e The ovary, confifting of twelve oviducts, fix at a fide, and ftill containing eggs of different fizes, or in which there moreover appear eggs of different fizes.

f The vulva.

g A bag, fhaped like a pear, opening into the vagina of the uterus.

h A blind veffel, which in the infect appeared like a tranfparent lymphatic veffel.

i Another particle, communicating with that laft mentioned, and containing a hard white fubftance.

k k k k Pulmonary tubes, and veficles, diftributed in great numbers amongft the foregoing parts.

l A confiderable branch of thefe tubes and veficles, running at one end of the common ovary duct.

m Some other fmaller branches belonging to the ftomach and inteftines.

TAB. XXXI.

The Hiftory of the Arborefcent Flea.

FIG. I.

The arborefcent Flea.

a The aquatic aborefcent Flea, a little bigger than nature.

FIG. II.

A fide view of the faid Infect, taken with a microfcope.

a One of the eyes, fituated at one fide of the fnout.

b b Its branching arms, iffuing from a fingle trunk. Each of thefe branches terminates in two branches, which are again divided into joints and lateral hairs.

c The infect's fharp fnout, with which it fucks its prey.

d Its fcaly fkin, with an opening in it, through which it can thruft out its body and tail.

e The tail, or extremity of the body, in which there appears an inteftine through the tranfparent furrounding parts; the feet are to be feen in the fame manner on the fore part of the body, near the opening in the fkin juft now mentioned.

f The extreme point of the rhomboibal fhell, that covers the body.

h Tranfparent eggs, which lie on the fore part of the infect, upon its pellucid body, with which they move backwards and forwards.

FIG. III.

A more front view of the arborefcent Flea, with the opening in its fkin.

a An eye. *b b* The branching arms.

c The fnout.

d The flit, or opening in the fkin, reprefented in its natural condition, but fomewhat on the fore part, in order to exhibit the legs now projecting beyond it.

e f The tail, and its hairs, a little more thruft out from under the faid opening.

g The fharp point, or extremity of the infect's fcaly fkin.

h That part of the body, in which the eggs lie.

A fhort Hiftory of the Gnat.

FIG. IV.

The Worm, which turns to a Gnat, of its natural fize, viewed in different fituations.

FIG. V.

The fame Worm viewed with the microfcope, fo as to fhew its thorax and belly, and in what manner it can fufpend itfelf on the furface of the water, by means of the appendages of its tail.

a a The eye. *b b* The antennæ, or horns.

c The mouth, with its hairy parts, and articulated briftles.

d d The thorax, with its hairs and divifions. On diffecting this Worm, feet are found laid up under the faid regular divifions.

e e Eight divifions of the belly, with its briftly hairs.

f The tail.

g An appendix to the tail, through which appendix there appear two pulmonary tubes, through which the infect breathes.

h Black fpots, hairs, and little hollows on the extremity of the faid appendage. It is by means of thefe the Worm fufpends itfelf on the furface of the water

i Bubbles of air, difcharged by the Worm from the appendage of its tail.

k k The

k k The two main trunks of the pulmonary tubes, ſhewing themſelves through the belly. Theſe trunks have their mouths in the appendage of the Worm's tail.
l The anus diſcharging ſome excrements.
m Excrements diſſolving in the water.
n A little tranſparent inteſtine, ſhewing in what manner the excrements are extruded.

FIG. VI.

The great Worm changed to a Nymph, of its natural ſize, in two different ſituations.

FIG. VII. and VIII.

Two repreſentations of the ſaid Nymph ſomewhat magnified, One of theſe repreſentations conſiſts of nothing but outlines, the better to exhibit the parts of the inſect, which it is intended to repreſent.

a One of the eyes on the ſide of the head. The head itſelf at this time lies higher up.
b One of the two antennæ. divided into black joints.
c A ſting, or prickle, with its ſharp point lying between the wings.
d d d d The legs; the hinder ones coiled up in a very ſurpriſing manner, and lying for the moſt part under the wings, through which however, thoſe belonging to one ſide ſhew themſelves in this figure.
e e One of the wings.
f f f Eight rings of the body.
g g A beautiful edging belonging to the belly.
h The tail, now hanging down, with its rowing fins.
i i The antennæ of the Worm, altered by caſting a ſkin. It is by means of theſe antennæ, that the Nymph now hangs by its head on the ſurface of the water, and in this ſituation breathes, and is enabled to perform its mutation with the greater facility.

TAB. XXXII.

FIG. I.

The male Gnat, of its natural ſize.

FIG. II.

The male Gnat viewed by the microſcope.

a a The eyes, reſembling a net.
b b The antennæ, much more beautiful than thoſe of the female.
c c One pair of the antennæ, or articulated briſtles. each of which conſiſts of three joints.
d The external ſheaths of the ſting.
e The ſting itſelf, or one of the five ſtings projecting beyond the ſheath.
f f f f The Gnat's ſix legs, conſiſting each of ſeven joints.
g g g g Sharp, ſcaly, feathers growing on the two wings.
h h Two little hammers, againſt which the Gnat ſtrikes its wings, and ſo makes a buzzing noiſe
i i The thorax, covered with ſtiff hairs.
k k The belly, conſiſting of eight rings, as in the Worm.

FIG. III.

The ſtings of the Gnat, and their internal ſheath, or horny channel.

a The external ſheath of the ſting, cut off near the head, and ſeparated from the ſtings, and their channel.
b The internal tubulated ſheath, or channel, containing five ſtings. The blood flows in this channel along or amongſt the ſtings. There are beſides in here two drops of a tranſparent liquor or humour, which perhaps is the poiſon ſaliva that produces the the tumour, in the wounded ſkin.
c c The very ſlender ſtings, extracted from the ſaid channel.
d d d Three thicker ſtings, pulled likewiſe out of the ſaid channel.
e The neck of the Gnat ſeparated from its body.
f The head.
g g The eyes of a reticulated form.
h h The horns cut off.
i i A pair of articulated briſtles cut off likewiſe.

FIG. IV.

The head, and ſting of the female Gnat.

a a The antennæ, or horns, which differ conſiderably from thoſe of the male.
b b The ſhorter articulated briſtles.
c The external ſheath of the ſting.

FIG. V.

The female Gnat of its natural ſize.

TAB. XXXIII.

Which exhibits the nocturnal Butterfly or Moth.

No. I. The Worm or Caterpillar of the nocturnal Butterfly, ſticking in its firſt coat or ſkin, and of its natural ſize.
II. The hardened ſhell of the egg, divided into two parts, as quitted by the Worm.
III. The Caterpillar itſelf, having attained its full ſize, remarkable on account of its wonderful form.
a Four little bundles of hair, behind the head, like ſo many cloaths bruſhes, clipt even at the tops; they are of a white colour, inclining to yellow, and ſet along the back.
b b Two other bundles of black hairs of unequal lengths, placed about the fore part of the head, and which appear like horns.

c c Two

c c Two other feathers, like bundles of hairs, placed on each ſide of the breaſt like oars.
d d Two more, like the firſt, but not ſo beautiful; of a yellowiſh white.
e e Shorter feathers like hairs, placed all over the ſkin, and interſperſed with other longer ones.
f The feather-like ornamented tail.
IV. The ſame Caterpillar wound up in its web, ſhortly to undergo its change.
a a a The web, in which the Caterpillar has ſettled itſelf.
b The third and fourth ring ſwelled by the increaſe of the limbs within the Butterfly.
V. The ſame Caterpillar changed into a Chryſalis, or Aurelia, which in a little time is to become a male Butterfly, the limbs of the Butterfly that is by and by to be produced, are now viſible, tho' obſcurely.
VI. The male Butterfly produced from the former Chryſalis, in which may be ſeen
a a Its elegant horns. *b* Its ſmall body.
c c Its large wings, which are wanting in the female.

FIG. I.

The egg of the nocturnal Butterfly, ſhewn in No. I. *in its natural ſize, is here repreſented as magnified.*

FIG. II.

The egg, broken open by the inſect that ſtuck in it, repreſented as magnified; which was ſhewn of its natural ſize, No. II.

FIG. III.

The web quitted by the Catepillar, with the perforation it makes when about to be changed into a Butterfly; ſhewing how the eggs are glued in it, which are laid by the female Butterfly, which in like manner are afterwards to produce Caterpillars,

FIG. IV.

The Chryſalis of No. V. *repreſented, exhibiting all the external parts of the future male Butterfly: namely,*

a The two eyes in the head, under which ſtretched againſt the thorax is diſcerned the proboſcis or trunk.
b The antennæ, or horns, removed from their natural ſituation.
c c The ſix legs, alſo removed out of their proper place, that they may be the more eaſily viewed.
d d Two pair of wings.
e The wings of the abdomen.

FIG. V.

The Chryſalis of the female Butterfly, exhibiting again all its limbs and parts; as conſtructed in their natural ſituation.

FIG. VI.

The female nocturnal Butterfly, repreſented No. IV. *but far more imperfect in its limbs and parts than the male.*

a a Its two leſs elegant horns.
b The thick and diſtended body.
c c The four ſhort wings, or which may be rather called imperfect rudiments of wings.

FIG. VII.

The female, with her belly diſtended with eggs.

a The ſkin upon the back cut open and turned backwards, to ſhew the great number of eggs with which the belly is filled.

TAB. XXXIV.

The Hiſtory of Day-Butterflies.

FIG. I.

The Caterpillar from which the common Dutch day Butterfly is produced.

a Its external form, which is as it were ſet thick with prickles.
b Three of the foremoſt of its ſix legs.
c Four of the middlemoſt hinder legs.
d The two hinder legs.

FIG. II.

The Caterpillar magnified, exhibiting its thirteen annular diviſions.

1. The firſt annular diviſion or ring, conſtituting the head, in which
a a On each ſide are ſix eyes.
b b The antennæ or horns.
c c The teeth, placed under and near the lip.
d The little prominent particles, the middle moſt of which is formed like a papilla or nipple.
2. Another annular diviſion, with its briſtly hairs, which is called the firſt point of reſpiration, or breathing hole.
e Another of the firſt pair of legs, with its joints, having a crooked claw at the extremity.
3 4 The third and fourth ring, which have no breathing holes. The third ring, with the two larger ones alſo is beſet with ſmall prickles, of which only thoſe in the fourth are repreſented.
f Another of the ſecond pair of legs joined under the third ring.

g Another

g Another of the third pair of legs, joined under the fourth ring.
5. The fifth ring, on the other ſide of which there appear three prickly hairs.
h A prickly hair placed in the middle of the Caterpillar's body, like that which is placed on each of the twelve rings.
i The firſt and largeſt prickly hair, placed on the other ſide of the body; under and near which is ſeen a ſecond, and under it another breathing hole.
k A third prickly hair under the belly.
6 The ſixth ring, formed like the fifth, containing the third breathing hole.
7 8 9 10 Theſe rings are conſtructed in the ſame manner with the two former, in which appear the fourth, fifth, ſixth, and ſeventh breathing holes.
l l l l Four of the middlemoſt legs, together with their fleſhy articulations and crooked claws; joined in the bending part of the body, each with its ring.
11 The eleventh ring, formed like the former, in which is placed another of the eighth pair of breathing holes.
12 The twelfth ring, differing from the reſt in the number of its prickly hairs. The reſt of the nine breathing holes above it, are ſeen placed in this ſide of the body.
13 The thirteenth ring, adorned at leaſt with two prickly hairs.
m m The tail and the laſt pair of legs, placed in the extremity of it.

FIG. III.

The kidney-like little parts.

a a The diviſions which appear on the ſurface of theſe kidney-like parts.

FIG. IV.

The ſtomach, and its parts.

a The gullet, which runs naturally through a ſlit in the ſpinal marrow.
b b b b Some pulmonary tubes diſperſed over the ſtomach.
c c A tendinous ligament of the ſtomach.
d d d Muſcular tranſparent fibres of the ſtomach.
e e The vaſa varicoſa, or ſwollen veſſels, which are the cloſed inteſtines, conſtituting, as it were, twelve little inteſtines.
f f The place, in which theſe inteſtines, below the pylorus, are produced from the inteſtine next the ſtomach.
g g The manner in which the ſame is bent into ſix little tubes, and turned back towards the ſtraight gut, againſt which they are folded and curled.
h h Their windings and foldings,
i One of the thick inteſtines, in which the excrements receive their form; ſo that it is not unlike the colon.
k The ſtraight gut.

FIG. V.

Two veſſels hitherto unknown, which lie in folds near the ſtomach

a a Two tubes, which might very well paſs for ſilk bags.
b b The origin of theſe tubes, aſcending towards the brain; they are very narrow in this place.
c Swellings in theſe tubes.
d Their ſharp extremities, inſerted lower down near the blind guts.

FIG. VI.

The heart.

a a The hollow channel of the heart.
b b b, &c. Muſcles ſituated on each ſide of the heart, which they ſerve to dilate.

FIG. VII.

The brain and ſpinal marrow.

a The brain. *b b* Origin of the ſpinal marrow,
c The firſt nodule of the ſpinal marrow.
d d Two pair of nerves, ariſing immediately from the ſpinal marrow, which produces three pair more in the ſame manner.
e The ſecond nodule of the ſpinal marrow.
f The fourth and greateſt cleft or ſlit of the ſpinal marrow, below the third nodule.
g h The fourth and fifth nodules, with the ſingle nerves ſpringing from them.
i k l m n The ſixth, ſeventh, eighth, ninth, and tenth nodules of the ſpinal marrow, with the four nerves iſſuing from each nodule.
e The eleventh and laſt nodule of the ſpinal marrow, with the nerves that it produces,

TAB. XXXV.

FIG. I.

The web formed by the Caterpillar, when about to enter the Nymph ſtate.

a The Caterpillar's web, in which it fixes the nails of its hinder feet, and ſo remains ſuſpended head downwards.
b The third and fourth rings of the thorax, conſiderably diſtended by the blood and air, that dilate the latent wings and legs.
c Eight intermediate legs, which loſe their ſkins by degrees, and are at length ſlipt off towards the tail.
d The firſt order of legs, which are likewiſe about to ſhed their ſkins, and roll off one over another.

FIG. II.

The limbs of the future Butterfly, that grew out of fight under the prefent infect's fkin.

a a Its two antennæ or horns.
b b The two fhanks of the probofcis.
c c Parts like forks.
d d The eyes.
e e The upper and lower pair of wings, between which are to be feen the legs growing from the thorax.
f f The rings of the body. *g* The tail.

FIG. III.

The natural difpofition of fome of the latent limbs reprefented by the laft figure, as appears through the microfcope.

a a The place where the horns or antennæ are jointed with the head, and from thence are regularly turned back, and folded in a ferpentine manner.
b b The two fhanks of the probofcis, difplaced a little from their natural fituation.
c c The forky particles in their natural fituation.
d d The eyes in their natural fituation.
e A portion of the fkin, that lay over the middle of the fkull, which is in this place removed.
f f The root of the probofcis.
g The forks, between which the infect, when become a Butterfly, curls up its probofcis.

FIG. IV.

The Caterpillar beginning to fhed its fkin.

a a The eight intermediate legs rolled off towards the tail, and fhedding their fkins.
b The fix fore feet, feparating from each other, and flipping forwards.
c The fkull divided into three parts, the middlemoft of which is here reprefented.
d Another portion of the divided fkull.
e The third portion.
f f The forky particles, which are the parts of the future Butterfly, that appear firft.

FIG. V.

The Caterpillar in greater forwardnefs towards the Chryfalis ftate.

a a The eight intermediate legs now driven higher towards the tail.
b Four of the fore pair of legs rolled off as far as the middle of the body.
c d The forky particles entirely divefted of their fkin; and the divided fkull; and the firft pair of the fix fore legs rolled off higher upon the body.

FIG. VI.

The Caterpillar after it has quite thrown off its fkin; fo as to acquire the name of Chryfalis.

a The wings, horns, probofcis, and legs, all of them extended, and of another form.
b The rings of the abdomen ftripped of its fkin: Thefe are now more compreffed towards each other than heretofore. It here appears in what manner the Chryfalis, by means of the nails in its tail, continues fufpended by its web.

FIG. VII.

All the parts or limbs juft now mentioned, as they appear through the microfcope.

a a The forky particles, which are no longer to be feen in the Butterfly. The third figure exhibits them under the letters *c c*, in their natural fituation.
b The middle portion of the head, which heretofore lay under the fkull, and is reprefented in the laft mentioned third figure, under the letter *e*.
c c The root of the probofcis reprefented in the fame place under the letters *f f*.
d d The probofcis itfelf denoted by the letters *b b*.
e The extremity of the probofcis fo much extended, as to reach the rings of the abdomen, and placed between the antennæ.
f f The firft pair of legs.
g g The fecond pair.
h h The antennæ or horns, whofe origins or rudiments are exhibited by the third figure under the letters *a a*.
i i Their extreme ends, which are very thick.
k k The eyes, under which the horns lie bent. Thefe eyes are reprefented by the letters *d d* of the third figure.
l l l l The wings placed in each fide of the body.
m m The nervous divifions of the wings. Thefe divifions are in reality no more than pulmonary tubes.
n n The rings of the abdomen clofed and folded one over another.
o o Some prickly hairs like papillæ, divefted likewife of their fkins and feated on the infect's back, from which they project a little. More forwards may likewife be feen four breathing holes.
p The tail freed from its fkin, as likewife the anus.
q The nails of the tail, and the manner in the infect ufes them to faften itfelf to the web.

FIG. VIII.

The Chryfalis lying on its back.

FIG. IX.

FIG. IX.

The colour of the upper and largest pair of the future Butterfly's wings, as they very plainly appear through the transparent skin of the Chrysalis.

FIG. X.

The cast skin of the Chrysalis, dividing into four segments.

a The first part of the divided skin. This part contained the Butterfly's two fore-pair of legs, and its proboscis.
b b The skin of the back, and abdomen, divided into two parts, that served to enclose the thorax, head, and four wings.
c The skin tore off near the origin of the abdomen, whose rings it heretofore contained.
d Some of the internal membranaceous cases, or integuments of the horns, legs, and proboscis. These membranes are always broken on the Chrysalis's first appearing in the Butterfly form.
e e Some pulmonary tubes, divested of their integuments, and appearing in the skin itself.

FIG. XI.

The Butterfly, lately stript of its skins.

a Part of the body, which the wings do not as yet cover.
b b The small spots and colour of the wings.
c c c c Four legs of the insect.
d d The antennæ, or horns, growing over the the eyes, which are surrounded with hair. Between the horns are two shaggy forks, which hide the proboscis.
e The two shanks of the proboscis, hid between the said forks.

FIG. XII.

A Butterfly, which in little more than a quarter of an hour after its first appearing as such, has acquired its full growth and perfection, so as already to know what it ought to seek after, and what avoid; what may be useful to it, and what prejudicial. In this respect then, the Butterfly infinitely surpasses all other creatures, even man himself; and with a most audible voice, as it were, publishes to all mankind, the praises of their common Creator.

TAB. XXXVI.

FIG. I.

The stomach, and contiguous parts, with the vasa incognita, or unknown vessels, heretofore described; all which parts are now altered in a most surprising manner.

a a Folds and turnings of the vasa incognita, exhibited already, Tab. XXXIV. Fig. V.
b Their origin, consisting of a slender tube.
c c Their divisions and dilatations.
d The end of them, near the origin of the stomach.
e e The two curled-up or coiled shanks of the proboscis.
f The origin of the gullet, near the root of the proboscis.
g The channel of the pulmonary vesicle or bladder, arising from the gullet.
h The pulmonary bladder, or vesicle itself.
i i The stomach, consisting of many beautiful curled prominences.
k The hinder part of the stomach, like a wrinkled intestine.
l l l l Six vasa varicosa, or swollen guts, springing by two origins from the little intestine below the pylorus.
m m The straight guts, with their twists, and globular contents appearing through them.
n The intestine considerably dilated, so as to form the cloaca.
o Another dilatation of the intestine.
p The straight gut. *q* The anus.
r r The two muscles of the anus, furnished each with a tendon of a substance between bone and horn.

FIG. II.

The genitals of the Male.

a The penis, consisting partly of a horny bone, and partly of a nervous texture.
b b Two horny bones, situated one at each side of the penis.
c The articulation of these bones, with a border of the same substance, that goes round the penis in the form of a belt.
d d Another horny bone, belonging to the penis, divided in the middle.
e A back view of the division of the said part.
f The nervous root of the penis.
g g The body or root of the penis, beautifully curled or coiled.
h A granulated matter, like silver sand, that flowed from a puncture made in the penis.
i The opening of the root of the penis.
k The division of the nervous part of the penis.
l l l l Two beautifully curled seminal vessels, issuing from the division of the penis.
m m Two other straighter vessels, springing from the same division.
n A globular dilatation of the said vessels.

FIG. III.

The ovary, and its parts.

a a a a a The oviduct, divided at each side into three ducts, which afterwards terminate in very sharp points.
b b The common ducts of those already mentioned, ending in a single trunk.
c c c c c Five vessels, containing a glutinous substance,

ſubſtance, with which the Butterfly faſtens its eggs.

d The ovary, contracted into a narrower tube.

e An oblong bag, in the ſame place.

f Part of the ſaid bag, full of a yellowiſh matter.

g The lower part of it, full of a limpid humour.

h A little tranſparent part, like a ſheath or caſe, that contained a little horny bone.

i The aperture of the ſaid little horny bone.

FIG. IV.

The fat.

a a Some pulmonary fiſtules, ſerving to bind up the fat.

b b b The figure of the fat itſelf, very different from what it had in the Worm.

TAB. XXXVII.

The Butterfly encloſed in the Caterpillar.

No. I. The Butterfly, under the Caterpillar form, covered with its firſt ſkin, in which it is called an egg, and lies in the ſame manner that the Butterfly lies within the ſkin of the Chryſalis.

II. The ſaid firſt ſkin, or membrane, after it has been caſt off.

III. The Butterfly-Caterpillar, or the Butterfly in the form of a Caterpillar.

IV. The ſaid Caterpillar drawing near its change, and containing, within its ſkin, the Butterfly, expreſſed by the I. II. III. and IV. Figures.

a Its protuberant limbs and wings, which are not diſcernible about the ſecond annular ſection of the body.

b The ſame limbs, ſprouting out under the third ring.

c The hinder part of the body, growing ſmaller by degrees.

d d The beam to which this Caterpillar had faſtened its ſlight web.

e That part of the web, in which it had fixed the nails of its hinder feet.

f f A ligament compoſed of threads, with which the Caterpillar had girt itſelf about the middle of its body.

V. The Butterfly-Caterpillar, after it had ſhed its ſkin, in the Chryſalis form. This number ſhews all the limbs of the Butterfly already exhibited by the fourth, but more obſcurely, and diſpoſed in a different manner.

VI. The Butterfly itſelf, or Caterpillar-Butterfly, with its wings extended, and arrived at its full growth.

FIG. I.

The egg of a Caterpillar, which is a Butterfly, repreſented bigger than nature.

FIG. II. III. and IV.

The Butterfly, extracted from under the ſkin of the Caterpillar, exhibited by No. IV.

a a Its antennæ, or horns. *b* Its proboſcis.

c c Its four wings, placed between its ſix legs.

d d Annular ſections of its belly.

FIG. V.

All the ſaid parts of the Butterfly, as concealed in the Chryſalis.

a a a a The antennæ. *b* The broboſcis.

c c Four legs lying on the upper wings.

d d The upper wings, and part of the lower wings.

e The head and eyes.

f The belly and tail, with their ſections.

FIG. VI.

The parts, juſt now exhibited, diveſted of all their coats, repreſented more diſtinctly, and in their natural ſituation, ſo as to give an opportunity of even diſtinguiſhing the Butterfly's colours.

FIG. VII.

Exhibiting a black ſpot, appearing through the external ſkin of the Chryſalis, in one of the Butterfly's tranſparent wings. It may be certainly known, by the appearance of this ſpot, whether the Chryſalis is ſhortly to caſts its ſkin.

FIG. VIII.

The caſt ſkin of the Butterfly-Chryſalis, which almoſt always divides regularly into four parts.

FIG. IX.

Shewing the manner in which the Butterfly, with its wings as yet very ſhort and little, creeps out of its laſt ſkin, under which it was called a Chryſalis,

FIG. X.

The manner in which the wings of the Butterfly, exhibited by the IXth Figure, expand by degrees, and acquire their full growth.

FIG. XI.

All the limbs of this Butterfly, with its wings, in a growing ſtate.

a a The two antennæ, or horns.

b The curled proboſcis. *c c* The upper wings.

d d The lower wings. *e e* The ſix feet.

f The belly, its hairs, rings, and little feathers.

TAB. XXXVIII.

The mutations of the common Bog-houſe Fly.

No. I. The egg of the boghouſe Fly, of its natural

tural ſize. The figure underneath repreſents it bigger than nature.

II. The double coat or ſkin of the ſaid egg, left by the Bog-houſe Worm, which at laſt changes to the Bog-houſe Fly.

III. The ſaid Worm newly hatched, a little bigger than nature.

IV. The ſaid Worm full-grown.

V. The ſaid Worm grown immovable, by degrees, under its ſkin, and changed to what I call a Vermiform-Nymph.

VI. The Bog-houſe Fly itſelf, proceeding from the Bog-houſe Worm, after the latter has changed into a Vermiform-Nymph, and and caſt off two ſkins.

FIG. I.

The egg of the Bog-houſe Fly, as it appears through the microſcope. It is oblong, full of angles, beautifully coloured, and teſſellated like the Dutch cakes, called Woffels.

FIG. II.

The double coat of the egg, broken by the Worm it contains. The external coat is of a ſubſtance like plaiſter; the internal coat, which is thinner, reſembles a membrane.

FIG. III.

The Bog-houſe Worm, as it appears through the microſcope, divided into annular ſections, and its body beautifully ſurrounded, as it were, with little tufts of feathers.

FIG. IV.

The ſame Worm changed into a Nymph, of a ſize bigger than nature, in order to ſhew that the little difference, as to external form, between this Nymph and the preceding Worm, (Fig. III.) conſiſts of no more than this, that in the Nymph ſtate the inſect's ſnout is drawn in within the head, and all the annular inciſions of the body are become ſhorter than they were in the Worm ſtate. Add that the inſect, in the Nymph ſtate, is deſtitute of motion, whereas in the Worm ſtate, it was very active and lively.

FIG. V.

The true or real Nymph, concealed within the Vermiform-Nymph, (No. V. and Fig. IV.) and thence extracted through inciſions made in the ſkin. This figure is a little bigger than nature.

FIG. VI. and VII.

The ſame Nymph (Fig. V.) viewed with a very great magnifier, the better to diſtinguiſh one from another; it's limbs, which are chiefly exhibited by the ſeventh Figure, and denoted by letters, as follows.

a a Are the reticulated eyes, between which, at the ſame time, may be ſeen the proboſcis, placed towards the thorax.

b The two antennæ, or horns.

c c The ſix legs, folded up on each ſide, againſt the thorax.

d d The folded wings.

e The abdominal rings, with the tubercles growing on the edge of the abdomen.

FIG. VIII.

The Bog-houſe Fly, (No. VI.) bigger than nature, with its external parts.

a a Two reticulated eyes, of a purpliſh colour, and parted by two ſilver belts or borders.

b Two antennæ on the forehead.

c c A pair of wings of a membranaceous ſubſtance.

d d d d Six hairy legs, the extremities of every one armed with nails.

e The abdomen, its rings, colour, and hairs.

FIG. IX.

A Another kind of Bog-houſe Worm, belonging to the ſecond mode of the third order or claſs. This worm is very remarkable on account of its legs and horns.

B The Vermiform Nymph of the Worm, from which it differs externally more than the Nymph heretofore exhibited, No. V. and Fig. IV.

C The Fly produced by the Nymph, elegantly covered, by ſome prepoſterouſly ranked amongſt Bees.

FIG. X.

D A white Worm, that grew within the Caterpillar of Tab. XXXVII. No. III. and aftewards, when near its time of mutation, opened itſelf a paſſage through the Chryſalis of the ſaid Caterpillar, repreſented by No. V. of the ſame Table.

E The ſame white Worm changed after its iſſuing from the ſaid Chryſalis, into a Vermiform-Nymph, that being opened is found to contain a real Nymph.

F The Fly at length produced by the ſaid Vermiform Nymph, after it has caſt its ſkins.

TAB. XXXXI.

The Hiſtory of the Aſilus, or Gadfly.

FIG. I.

The Worm from which the Gadfly iſſues, hanging over the ſurface of the water.

a Twelve annular diviſions of the Worm, by

 which

which it is divided, as it were, into head, thorax, and belly.

b Hairs growing round the tail, in a circular form, by means of which this part floats on the ſurface of the water, while the reſt of the body remains under water, with its downwards.

c The head, whoſe mouth is divided into three parts. The two lateral parts, which are, properly ſpeaking, the inſect's feet, vibrate, while it remains alive, like the tongues of ſerpents.

FIG. II.

Another kind of theſe Worms, in its deſcent to the bottom.

a The hairs of the tail, diſpoſed in an oval form, and containing a bubble of air within their cavity.

b Two bubbles of air, diſcharged by the Worm at its breathing-holes, tending to the ſurface of the water.

FIG. III.

A microſcopical view of the firſt Worm.

1 2 3, *&c.* Twelve rings, by which it is divided into head, thorax, belly, and tail. This figure likewiſe ſhews in what manner the ſkin is beautifully covered with minute grains and ſpots. On one ſide too there appear nine breathing-holes.

a The tail, reſembling a ſtar, compoſed of beautiful hairs.

b b Delicate hairs, which in this figure appear only about the ſides of the body, as I have omitted repreſenting them on its upper part, or on the inſect's back.

c c. Two larger hairs, growing on each ſide of the body.

d The head. *e e* The eyes.

f The crooked ſnout.

g g The legs, ſituated near the ſnout.

h h Two blackiſh horny bones, which are, as it were, the thumbs of the feet.

i i The horns, or artennæ.

FIG. IV.

The grains of the ſkin, viewed with a great magnifier, ſo as to ſhew their conſtruction.

a The ſkin appearing between the grains.

b The prominent part of the ſaid grains, exexactly in the middle.

c The irregular rings of the ſaid grains.

d Sharp prickles growing on the edges of the grains, to whoſe firmneſs they contribute.

FIG. V.

A leg, magnified.

a Three muſcles, furniſhed with a tendon, of a ſubſtance between bone and horn, and placed on one ſide of the firſt joint of the leg.

b The ſaid joint, which is black, and likewiſe of a ſubſtance between bone and horn.

c Two ſmaller muſcles, with their tendons.

d Another joint, of a ſubſtance between bone and horn.

e The extreme joint of the leg, with its briſtly hairs.

f The thumb of the foot.

FIG. VI.

The ſnout inverted, and bigger than nature.

a The ſnout, and all its parts.

b The ſharp and crooked extremity of the ſnout.

c The internal opening of the mouth, through which the inſect's food paſſes to the gullet.

dd The membranaceous diviſions of the mouth, by which the palate can be bent, and made to give way.

e Part of the mouth, entirely conſiſting of a black horny bone.

FIG. VII.

The ſalival veſſels, or at leaſt two parts analogous to ſuch veſſels.

a Two ſalival veſſels curled, and ending in blind extremities.

b A ſingle channel, in which they terminate.

c c Two particles, as it were, reſembling muſcles.

d The upper part of the mouth, from which the eyes, and two parts of the head, ſupporting the eyes, have been ſeperated.

TAB. XL.

FIG. I.

The Worms pulmonary tubes.

a a Two very conſiderable branches of the pulmonary tubes.

b Pulmonary tubes in that part where the optic nerves, and the membranes of the growing eyes, are ſituated.

c c c Some pulmonary tubes, which run into each other from each ſide of the body.

d d d d d d A mutual communication of the pulmonary tubes, at each ſide of the body, under the ſkin.

e e e e The circumference of the ſkin, denoted by dots.

f The tail, in which the two main trunks of the pulmonary tubes are opened by two channels.

FIG. II.

Curls or folds of the pulmonary tubes.

a a Two portions of the pulmonary tubes drawn aſunder.

b Their

b Their curly foldings, which reprefent a filver wire wound up in a fpiral form, and then extended.

FIG. III.

The fat.

a Irregular figures of the fat.
b Its round particles. *c* Its oblong particles.
d Its broad, jagged, or indented particles.
e Its angular particles.
f Particles in form of a pear.
g Pulmonary tubes diftributed through the fat.

FIG. IV.

The heart.

a a The lower part of the heart, in fome places a little dilated.
b b Part of the heart, reprefented bigger in the abdomen and thorax.
c Part of the heart, feated about the head, and again contracted.

FIG. V.

The brain.

a a The brain.
b A cleft or opening in the fpinal marrow, to give a paffage to the gullet.
c c Part of the eyes of a future Nymph, and Fly growing by degrees.
dd Eleven prominent nodules of the fpinal marrow
e e Nerves fpringing from the origin of the fpinal marrow.
f Nerves iffuing from the origen of the fpinal marrow towards the fides of the body.
g g Nerves fent from the eleven nodules of the fpinal marrow to the vifcera, and other parts.

TAB. XLI.

FIG. I.

The Worm changed within its fkin into a Nymph.

a a a The external fkin hardened, and contracted into three bendings.
b c d e The four laft rings of the abdomen, which, on account of the contraction of the body, contain nothing but air.
f A hollow or empty fpace in the external fkin, between the head of the Worm and the enclofed Nymph. This hollow appears more obfcurely than that under the four laft rings of the abdomen.
g The enclofed Nymph, known by a black fpot appearing externally on the fkin's furface.

FIG. II.

The fkin opened, fo as to give a fight of the enclofed Nymph.

a The Nymph ftill wrapped up in its thin and delicate fkin.
b b Its unfolded pulmonary tubes, of which there are four reprefented in this figure.
c The fkull caft off, with the other parts of the horny head, and the fnout.

FIG. III.

Parts of the future Nymph, difcerned in the Worm when ftripped of its fkin.

a a The antennæ, or horns.
b The head and probofcis.
c c The firft pair of legs. *d d* A pair of wings.
e e Another pair of legs. *f f* A third pair.
g The abdomen, and its rings. *h* The tail.
i i Pulmonary tubes, which have in part fhed their coats.
k Inteftines likewife, which have partly caft their coats.
l The anus cut off, but ftill hanging to the inteftines.

FIG. IV.

The Nymph, or parts juft now taken notice of in the Worm, difpofed in a beautiful manner, and much bigger than nature.

a a The antennæ, or horns.
b b The eyes, in which the hexagonal divifions do not as yet appear.
c The probofcis under the head.
d d. The firft pair of legs.
e e The fecond pair.
f f Two wings, elegantly folded.
g Annular divifions of the thorax.
h The third pair of legs.
i i Some black fpots on the infect's body,
k k k k Four openings of the lungs.

FIG.

The fat of the Nymph.

a Changes or alterations in the configurations of its parts.
b b Some ramifications of the afpera arteria diftributed through the fat.

FIG. VI.

The ftomach and inteftines of the Nymph, to which are added the head and tail of the Worm.

a The origin of the gullet.
b The horny bone of the head; the fnout, and the legs drawn in towards the body.
c The gullet running towards the ftomach, through a flit or cleft in the fpinal marrow, under the brain. Thefe particulars have been reprefented in this manner, to make them the more intelligible.
d The ftomach, with its wrinkled foldings, and pulmonary tubes.
e Oblong furrows in the ftomach.
f An open tube, appearing through the tranfparent coats of the ftomach, within which it is faftened.

g The

g The ſmall gut, forming ſix foldings.
h A little gut, within the former, where it likewiſe makes a variety of folds.
i i The curled windings of the ſaid little inteſtine.
k The dilatation of the ſmall guts, and places where it produces four blind guts, that ſpring from a common trunk.
l Places where the thick guts unite with the ſmall guts.
m m Some globular dilatations in one of the blind guts, and the wonderful diviſions of its contents.
n n Surpriſing windings and folds of the blind guts.
o The place where two of the upper blind guts unite into one.
p p Windings of another, or the other upper blind gut.
q q Windings of the third.
r The blind extremity of this laſt.
s s Windings of the fourth blind gut.
t The blind annular extremity of this laſt.
u Dilatations of the colon, in form of nodules.
x The larger dilatation of the colon.
y The two ſmalleſt dilatations of the colon.
z The anus, below the ſtraight gut.

FIG. VII.

The ſpinal marrow in the Nymph and Fly.

1 2 3, *&c.* Eleven nodules of the ſpinal marrow, now extended at full length, and drawn out one from another.
a The brain; and above it a rough draught of the tunicæ corneæ of the eyes, and their hexagonal diviſions.
b The firſt nodule of the ſpinal marrow, retaining its primitive ſituation.
c The four following nodules, which now form a conſiderable knot or ſwelling, at the ſame time that the ſixth, ſeventh, and eighth are are ſeparated one from another, and the ſpinal marrow between them is drawn out.
d The three laſt nodules, continuing in their former ſituation.

TAB. XLII.

FIG. I.

The external ſkin ſhed by the Gadſly, with the manner of its ſhedding it.

1 2 3, *&c.* Theſe numbers, placed in oppoſite ranks, ſhew the twelve rings of the Fly, or Worm's ſkin.
a The third and fourth rings: it is in this place that motion is firſt perceived in the Worm's ſkin, when the Fly is about to break forth. And for this reaſon theſe rings burſt open in a longitudinal direction.
b The third fore ring, or, counting from the tail, the tenth, which burſts open in a contrary direction into two parts, one of which continues faſtened to the ſecond, and the other to the fourth ring.
c The fourth ring opens almoſt in the ſame manner, only that it cleaves more in the middle.

FIG. II.

A general view of the external limbs and parts of the Gadſly.

a Its two antennæ, or horns.
b b b b The ſix feet, and their joints.
c c The wings. *d* The abdomen.

FIG. III.

A diſſection of the Gadſly. The external ſkin and internal coat ſhed by the Gadſly.

1 2 3, *&c.* Rings of the external ſkin.
a a Pulmonary tubes, rolled off, in the ſecond, third, and fourth rings.
b b The curled extremities of the tubes.
c An inteſtine, ſhed likewiſe by this inſect, containing ſome tranſparent particles like ſand, which ferment with acids.
d The caſt legs, ſnout, and eyes.
e The caſt ſkull.
f Coats or ſkins, ſhed by the gullet and the ſtomach.
g g The caſt internal coat, which immediately encloſed all the limbs of the Nymph.
h The place where the coat contained the Fly's tail.
i i Pulmonary tubes caſt off within the delicate little ſkin.
k The largeſt of theſe tubes, with its ramifications.

FIG. IV.

A rough draft of the manner in which the Inteſtine ſheds its ſkin.

a The internal coat of the inteſtine *b*. This inteſtine comes away full of grains of ſand.
b The inteſtine itſelf, remaining in the body.
c The anus, with the internal coat of the inteſtine *b*, ſhed by the inſect, ſtill faſtened to it.

FIG. V.

The proboſcis magnified.

a The two fore parts of the proboſcis, of an oval form.
b Hairs growing from the ſkin of the proboſcis.
c c Two articulated briſtles, or appendages of the proboſcis, ſpringing from within its root.
d A triangular horny bone, ſurrounding the root of the proboſcis.
e Another little bone like the laſt in ſubſtance, but of a different form.

FIG.

FIG. VI.

Some of the pulmonary vesicles.

a Its membranaceous part, which was full of air.
b The pulmonary tube, through which the air passes to the vesicle.
c Two lateral pulmonary tubes.

FIG. VII.

The genital parts of the male.

a The penis and its two appendages.
b b Two twisted horny bones belonging to the penis, and articulated with the sheath, through which the penis erects itself.
c The flexible part of the penis.
d d Two little black horny bones, forming a border round the extreme ring of the abdomen, and articulated with the former bones.
e e Places where the articulations appear.
f The nervous body of the penis.
g A dilatation of the root of the penis, with which the vasa deferentia, and seminal vessels empty themselves.
h h The testicles. *i i* The seminal vessels.
k k Short tubulated seminal vessels, laid bare in one of the testicles.
l Vessels for the conveyance of the seed.
m m Windings of the seminal vesicles, the extreme ends of which are dilated.

FIG. VIII.

The ovary of the female.

a a The ovary consisting of two parts.
b The last rings of the abdomen.
c c c Some protuberances of a substance between bone and horn, appearing like spots on the last abdominal ring.
d Hairs growing in the same place.
e e e Eggs belonging to one side of the ovary, as yet in their natural situation.
f The same eggs a little more magnified, and removed out of their natural situation. The remaining part of this ovary is marked by dots.
g Pulmonary tubes interwoven with the ovary.
h Some branches of the said tubes dispersed both within and without the coats of the eggs.
i i The greatest extreme branches of the said tubes.
k Two ducts of the ovary, by which the eggs are let out of the body.
l Three beautiful unknown particles, each supported by its stalk,
m The point of the inflexion of these tubulated particles.
n Their tubes and windings.
o That end of the tubes which lies nearest to the duct of the ovary.

TAB. XLIII.

The History of the Acarus, or Mite.

FIG. I.

The Acarus or Mite, of its natural size.

FIG. II.

A microscopical view of the Acarus.

1 2 3 4 5 6 7 8 9 10 11 12 The twelve rings of the body.
a The head, in which are seen two nails belonging to the insect's legs, with which, when about to spring or leap up, it compresses its anus.
b The larynges or tops of the aspera arteria, projecting beyond the skin.
c c The place where there issue from the main transparent trunks of the aspera arteria, two branches, which unite by a mutual anastomosis, or inosculation with the branches of the fourth ring.
d d d d d d d The inosculation of the pulmonary tubes, which appear through the remaining rings of the body.
e A particle of the fat appearing through the skin.
f f Some blind guts, appearing in the same manner.
g A considerable branch of the aspera arteria, which appears through the skin under the tenth ring, between the two principal branches of the trachea.
h A beautiful particle of fat, appearing under the eleventh ring, and near which may be discoverd the two extremities of the branches of the trachea.

FIG. III.

The manner in which the Worm bends itself into a circle, in order to prepare for leaping.

FIG. IV.

The manner in which the circular form changes to an oblong one; just as the Acarus is about to leap or spring.

FIG. V.

The feet, parts of the mouth, stomach, intestines, and some other viscera of the Acarus, as viewed with the microscope.

a a The feet or teeth, and nails.
b b Origin of the horny bony parts of the mouth, and palate.
c c Four appendages of the said parts.
d Horny bones, which serve to keep all the parts in their proper situation.
e The dilatation of the gullet, which I call the ingluvies.
f f Four blind appendages under the ingluvies.

g g The ſtomach, of a conſiderable length.
h h h Ramifications of the aſpera arteria, viſible in the ſtomach.
i Contents of the aſpera arteria, appearing through its tranſparent coats.
k k The origin of the blind guts, of which this inſect has four.
l l Two of the ſaid guts, containing a yellowiſh green ſubſtance.
m The two others, whoſe contents reſembled a coagulated ſubſtance.
n Pulmonary tubes, belonging to a blind gut, of the ſame kind.
o The pylorus. *p p* The colon.
q The ſtraight gut. *r* The anus.
s s Two particles of fat, and their diviſions, with which one of the blind guts is interwoven.
t t Two glandulous ſwellings, and channels of the ſalival duct, which runs along the gullet to the jaws in form of a ſlender tube.
v v Two other ſwellings, with their channels and pulmonary tubes.
x x Some particles of fat, and their diviſions.
y y Two other particles of the ſame kind, which ſhew themſelves in the ſame place like appendages in the form of a chain.

FIG. VI.

Diviſions of the particles of fat, magnified to a greater degree.

a a a Seven diviſions of the particles of fat, in which it is laid up in the form of oily, ſpherical particles.
b The manner in which the pulmonary fiſtules paſs through the cells that contain the fat.

FIG. VII.

The brain, ſpinal marrow, and nerves, bigger than nature.

a a The right and left lobes of the brain.
b b The nerves, iſſuing from the upper part of the brain.
c The nodules, formed by the ſaid nerves.
d d Two fine nerves, iſſuing from the ſaid nodules, and running to the muſcles of the head and legs.
e e Two pair of muſcles ſent by the ſpinal marrow to the muſcles of the thorax.
f f Two ſtrong nerves, with their dilatations, adminiſtering to the muſcles that ſerve to move the wings.
g g A great many fine nerves diſtributed amongſt the muſcles, and viſcera of the abdomen.
h h h Ramifications of the ſaid nerves.

FIG. VIII.

A ſide view of the ſpinal marrow and brain.

a The brain.
b The ſinus of the ſpinal marrow.
c A cleft in the ſpinal marrow for the paſſage of the gullet.

FIG. IX.

Some of the muſcles.

a a a The oblique deſcending muſcles with two bellies, of each of which, one of the tendons is inſerted into the muſcle itſelf.
b b The broad tranſverſe muſcles.
c c The The oblique aſcending muſcles.

FIG. X.

The Acarus, or Mite, contracted, in which condition I call it a Vermiform-Nymph.

FIG. XI.

The ſame, bigger than nature.

a The head and mouth.
b The tail and its tubercles.

FIG. XII.

The concealed Nymph, extracted from the contracted or ſhrivelled ſkin of the Acarus.

FIG. XIII.

The ſame Nymph, bigger than nature.

a The two horns of the future fly.
b b The eyes. *c* The proboſcis.
d d The firſt pair of legs. *e e* The ſecond,
f f The folded wings.
g g The third pair of wings.
h The rings of the body.

FIG. XIV.

Two flies iſſuing from the Acari, or Mites, of their natural ſize.

FIG. XV.

A microſcopical view of the male fly, produced by the Acarus or Mite.

a The antennæ or horns.
b b The firſt of legs, their joints, hair, and nails.
c c The ſecond pair. *d d* The third.
e e The wings and little hammers placed under them.
f The rings of the belly.

FIG. XVI.

The ſkins caſt by the Acarus, bigger than nature.

a The upper part of the torn ſkin, where the fly creeps out.
b The lower part.

FIG.

FIG. XVII.

The genital parts of the male.

a The horny part of the penis, curled in a surprifing manner.
b The membranaceous part of the penis.
c The fore end of the penis, which is here reprefented as it receives the vulva of the female, inftead of being received by it.
d The nervous root of the penis.
e The place where the root of the penis is dilated.
f f The tefticles of a yellowifh red.
g g The vafa differentia.
h h Spherical appendages of the veffels.
i i The feed bags. *k k* The proftata.

FIG. XVIII.

The external parts of the uterus and vulva.

a a The two laft rings of the body.
b b The firft joint of the extremity of the uterus, covered with hair, and furnifhed with two little black horny bones.
c c The fecond joint enclofed in the firft. The extremity of this fecond joint is likewife of a fubftance between bone and horn.
d The third and laft joint, formed of the faid fubftance, and covered with hair. This joint is received by the penis.

FIG. XIX.

One of the fixty-four oviducts.

a A perfect egg lying in the oviduct, of a white colour.
b Three imperfect eggs of a watery colour.

TAB. XLIV.

Obfervations on the Vermicles, or little Worms, found in the tubercles of the leaves of Willows.

FIG. I. II. and III.

Tubercles of Willow leaves, the eggs, and Worms reprefented by fix feveral figures.

FIG. I.

a The external fide of the leaf.
b b The internal fide.
c c The warts or tubercles, of an oval round.
d Others of an oblong form.
e Others full of wrinkles.
f Very fmall warts, which look rotten, as it were.
g Warts, or tubercles, growing on the greater or main nerves.
h Another on the extremity of the leaf
i Another growing on the nerve itfelf.
k Others, which rife on each fide to an equal height, above the coats of the leaf.
l Some on the ftalk of the leaf.
m Seven rudiments of tubercles exhibited on each fide of the leaf.

FIG. II.

n The egg, that is found in the rudiments of the tubercles.

FIG. I.

o A tubercle with a cleft in it, through which the egg may be feen placed in the middle.

FIG. II.

p An egg magnified, fo as to fhew the head and two eyes of the enclofed Worm, that appear through its tranfparent fkin.

FIG. I.

q The Bindweed Caterpillar, full grown.
r The fmall hole bored by it through the tubercle or wart.

FIG. III.

A microfcopical view of the fame Caterpillar.

s The eyes. *t t* The fix fore feet.
u Six of the twelve middle feet.
x The two hinder feet, next the tail.

FIG. I.

y The manner in which the Caterpillar thrufts its anus out of the hole, made by it in the tubercle, and thereby difcharges its excrements.
z z Two rufty coloured fpots of the Willow-leaf; one of them with a hole in it, within which may be feen the nerves of the leaf, and the excrements and head of another Worm, that lives in it. Fig. VIII. exhibits this Worm of natural fize.

FIG. IV. V. and VI.

The Fly's web, and the Fly itfelf; likewife thofe parts of the Fly, with which it bores itfelf a paffage through the tubercle or wart; in five figures.

FIG. IV.

a The oval web of the Fly.
b The Fly itfelf.

FIG. V.

The Fly feen through the microfcope.

c The antennæ or horns.
d d The black fpots on the wings.
e e Six legs, their joints and two nails to each leg.

FIG. VI.

The parts with which the female bores the leaf.

f f The laft rings of the abdomen.
g An inftrument like a faw.
h h Two pointed horny bones.

FIG.

F I G. IV.

i A little lid or cover, which the Flies at their first appearance thrust out of their web, as out of a little barrel.

F I G. VII.

A microscopical view of a very small insect, which rests on the external surface of the Willow tubercles or warts.

F I G. VIII.

The little Worm found between the coats of Willow leaves, of its natural size. See Fig. I. let. *z z*.

F I G. IX.

A microscopical view of the same Worm.

a The head and two teeth.
b b Its broad thorax, and transparent pulmonary fibres.
c c The other rings of the body, which is covered with hair, and ends in a pretty sharp point.

F I G. X.

The Nymph, in which the Worm is afterward exhibited changed, a little magnified.

F I G. XI.

The same Nymph more magnified.

a Two crooked bristles on the head.
b b Its horns and antennæ.
c c The second and third pair of legs: The second is armed with two bristles.
d d Two sheaths to cover the wings.
e e The third pair of legs, and their bristles.
f The wings of the body, and the prickles and stings of the tail.

F I G. XII.

The Beetle produced by the said Nymph.

F I G. XIII.

The same Beetle magnified.

a Its reticulated eyes.
b Its snout or beak, of a substance between bone and horn.
c c Its antennæ or horns.
d d d Its six Feet, upon the least pair of which this insect makes it springs or leaps.
e e The sheaths of the wings.

F I G. XIV.

Rudiments of Willow leaves just beginning to shoot or bud.

a Four of there young leaves, with their stalks and rough surfaces.
b Red Worms, generally found within the leaves.

F I G. XV.

A microscopical view of a Fly produced by one of the Worms.

F I G. XVI.

A tubercle or wart growing in the Willow in form of a rose.

a The tubercle and its stalk.
b A pyramidal cluster of leaves, within which the Worm lies.

F I G. XVII.

Representing in five figures all the changes of the Worm, and its tubercle.

c The manner in which the leaves of the tubercle may be separated one by one.
d Part of the Worm's body, that lies in the middle of the cluster.
e A delicate membrane or web, more immediately enclosing the Worm.
f The Worm itself. *g* Its Nymph.
h The Fly to which the Nymph changes.

F I G. XVIII.

An Alder leaf with various Worms between its two coats.

a The coat of an Alder leaf swelled into a tubercle, on account of the Worm that had made its bed under it.
b b The upper coat or skin removed, in order to shew on each side, how the other coat is contracted underneath into a small fold.
c The web enclosing a Chrysalis, dissected; and near it the excrements of the Worm formerly contained between the two coats of the leaf.
d Another Worm with six feet, found likewise between the coats of the Alder.
e A third species of Worms found in the same place, with the skin cast by it, and its excrements.
f Two oblong webs made in their cells by the said Worms.
g Part of the leaf, where the same Worm is found, when as yet very small.
h The same part, where the Worm has made itself more room.
i Another cell or nest like the former, but a great deal more spacious.

F I G. XIX.

A microscopical view of a Chrysalis found in its web within the coats of an Alder leaf.

a The sharp pointed head of this Chrysalis.
b The hinder part of its body, formed like a pear.

c c Fine

c c Fine hairs growing on its body.
d d Its eyes. *e* Its probofcis.
f f Its firft and fecond pair of legs.
g g g g Its anntenæ or horns. *h h* Its wings.
i The laft pair of legs lying between the antennæ.
k k The rings of the body.

FIG. XX.

The Butterfly produced from the forgoing Chryfalis, drawn after nature.

FIG. XXI.

A microfopical View of the fame Butterfly.

a a The antennæ. *b* The probofcis.
c c The upper pair of wings, beautifully coloured.
d d The lower pair of wings, for the moft part covered with feathers.
e e Three white hairs, like thorns, growing on the hinder legs.

TAB. XLV.

A fhort explanation of the figures ferving to illuftrate fome of the foregoing hiftories.

FIG. I.

The manner in which the Fly lays its eggs, within the leaves of the common Thiftle; which eggs afterwards produce Worms.

FIG. II. III. IV. and V.

The Tubercles or Warts of the flinging Nettle, with the Worms and Nymphs found in them, and the Flies produced by the faid Nymphs, in four Figures.

FIG. II.

a Some excrefcencies growing on the ftalk.
b Some tubercles or warts of the fame kind, on the nerve of the leaf, and on the rudiments of the young leaves.
c Others growing irregularly on the leaf.

FIG. III.

d The Worm found in the tubercles of the Nettle, of its natural Size.
e A microfcopical View of the fame, fomewhat broader in the middle.
f A fine or flender fnout projecting from its extremity.
g Fine hairs growing on its body.

FIG. IV.

h The Nymph magnified to a greater fize, with very large eyes in its head. Here are likewife to be feen its horns, legs, wings and abdominal rings.
i Its little tail bent backwards.

FIG. V.

k The Male Fly of its natural fize.

FIG. VI. VII. and VIII.

The downy excrefcencies growing upon Oak trees, with little hollow bags or tubes, and the Flies engendered and living in them.

FIG. VI.

a a a The circumference of the downy ball or globe, after its natural condition.
b The ftalk fupporting it.
c An Oak leaf growing out of the middle of the ball.

FIG. VII.

d Bags or tubes, within which the Worms turn into Flies, and in whofe circumference the downy hairs of the ball are principally rooted.

FIG. VI.

e e Little holes, which the Flies gnaw in the downy fubftance in order to efcape out of their cells.

FIG. VIII.

f The Fly itfelf of its natural fize.

FIG. IX. X. and XI.

The fpongy tubercle of the wild Rofe: The fame laid open in the middle: Laftly, the Flies bred in it.

FIG. IX.

a a Knobs and inequalities of the tubercles.
b The ftalk fupporting it.

FIG. X.

c A fection thro' the middle of the faid tubercle, fhewing the cells in which the Worms grow to be Flies.

FIG. XI.

d The firft fpecies of Fly that iffued from the faid tubercles, with a pretty thick body.
e The other fpecies of the bifeta, or two haired kind.

FIG. IX.

f Round holes knawed by the Flies in the fpungy tubercle, in order to get out of their cells.

FIG. XII. XIII. XIV. XV. and XX.

The tubercles or warts growing on Oak leaves: One of them opened: The kidneybean-like fubftance found in them: A tubercle cut off from the leaf: A microfcopical view of the bean-like fubftance: The manner in which the tubercle dries up or withers.

FIG. XII.

a a Excrefcencies found on the fore end of the leaf, and likewife a little higher up, on the leaf's nerve or main rib.

b Two tubercles; one of them a double one, growing ftill a little higher up on the nerve or main rib; the other almoft on the edge of the leaf.

c c Some tubercles on the extremities of the leaf.

FIG. XIII.

Containing five drawings.

d The upper part of one of the tubercles cut off.

e Three diftinct excrefcencies like kidney-beans, found in the hollow of the tubercle.

f Three excrefcencies like beans, taken out of the hollow cell or cavity.

FIG. XIV.

A tubercle or wart of the fame kind cut open, and exhibiting two kidney-like beans lying in it, in the fame manner that a preferved almond lies within its candied covering, without any intermediate vacancy. This is a microfcopical view, fhewing the objects a little larger than nature.

FIG. XV.

g The bean-like fubftance, with an uneven furface.

h That part of the bean, by which it principally adhered to its tubercle, and received its nourifhment.

FIG. XX.

i i The manner in which the tubercle begins to leffen, and wither up by degrees, fo as to become fit for the impreffion of the Fly's teeth, and thereby afford it an opportunity of efcaping.

FIG. XII.

k A fmall round hole, gnawed by the Worm in the withered part of the tubercle, and thro' which it iffues into the open air.

l l Places where the tubercles dry up, and which may be feen without cutting it.

m The Worm cut out of its bean-like part, and reprefented of a fize bigger than nature, on an Oak leaf.

FIG. XVI.

The fame Worm ftill more magnified, and of the form in which it appears, when about to enter the Nymph ftate.

FIG. XVII.

The fame Worm changed into a Nymph, and viewed with a greater magnifier in order to fee its limbs more conveniently.

a a Its eyes, refembling a net.

b b The antennæ lying between the legs and the wings.

c The abdominal wings.

FIG. XVIII.

The fame Nymph, changed to a Fly, of its natural fize.

FIG. XIX.

The fame magnified.

a a The antennæ placed before the eyes.

b b The four wings.

c c The leaft pair of its fix legs, every one of which is armed with two nails.

d The fharp extremity of the abdomen, with which the Fly bores holes in the Oak leaf for the reception of its eggs.

FIG. XXI.

Reprefenting, in two drawings, the excrefcence growing on the leaves of the black Poplar, with the Worms and their food contained therein.

a A wrinkled excrefcence in the external coat of the leaf.

b The principal rib of the leaf.

c The internal fide of the leaf, where the wart or tubercle opens into a flit or opening.

d d Windings of the principal nerve or rib, in the external coat of the leaf.

FIG. XXII.

A microfcopical view of one of thefe very minute Worms, that is furnifhed with two horns, two eyes, and fix feet; and is moreover divided into head, thorax, and abdomen.

e A woolly or downy fubftance, which thefe little infects very beautifully wear on the hinder part of their bodies.

FIG. XXIII.

f The infects glutinous food, contained within the woolly or downy fubftance, and refembling a veffel with a fpout ufed to feed infants.

g The manner in which the downy fubftance curls up, when its moifture is confumed.

FIG.

FIG. XXIV.

b b Two pair of cups or membranaceous buds, in which the wings grow, and are enclofed as it were in little bags.

FIG. XXV.

A microfcopical view of the fame Worm changed into a Fly with four wings.

FIG. XXVI.

The footlefs Worm, found on the leaves of the Cabbage, of its natural fize.

FIG. XXVII.

The fame Worm changed into a Nymph, reprefented lying on its belly, and of its natural fize.

FIG. XXVIII.

A microfcopical view of the fame Nymph, and in the fame pofture, with its limbs as appearing through their tranfparent integuments.

a a The eyes.
b The thorax and fome of the hairs growing on it.
c c c The abdominal rings.
d One of the rings
e The curled, or folded, caft off fkins, of a pulmonary tube.
f f Part of the Cabbage leaf, to which the Nymph glues itfelf by this membrane.

FIG. XXIX.

A microfcopical view of the fame Nymph, divefted of its caft fkins, and placed on its back.

a An eye, of one fide. *b* The two horns.
c The probofcis. *d d* The folded wings.
e The hinder pair of legs.
f f The extremities of the genitasl, which lie, as it were, out of the abdomen.

FIG. XXX.

The Fly of the faid Nymph, of its natural fize.

FIG. XXXI.

The cell, or neft of the Moth; the enclofed Worm of the Moth; the fame extracted; likewife its Chryfalis and Butterfly; alfo the manner by which the fkin of the Chryfalis remains faftened to the fore end of the cell or neft: Laftly, the very fine threads or filaments, with which the neft or cell is lined.

a The cell, fpacious in the middle, but narrower at each end.
b The thread formed by the Worm, and by means of which, to avoid falling, it hangs and faftens itfelf to the beams and walls of buildings.
c The manner in which the Worm of the Moth creeps out of its cafe or cell by the fore feet, and faftens itfelf with a thread of its own fpinning, in fome convenient fituation.
d The Worm itfelf of its natural fize, with fixteen feet.
e The fame changed into a Chryfalis.
f The Chryfalis changed into a winged Butterfly or infect, called a Moth.
g The caft fkins of the Chryfalis, projecting a little beyond the cafe.
h The internal furface of the cafe, very even and fmooth.

FIG. XXXII.

A fmall Worm found in mufk-bags, and its changes.

a The Worm. *b* Holes made by it in wood and paper.
c Its oval web. *d* Its Nymph.
e The Beetle produced by the faid Nymph.

FIG. XXXIII.

A Worm found upon leaves, in very black cafes.

a The manner in which the Worm carries its cafe about with it.
b The Fly produced by the faid Worm.

FIG. XXXIV.

Another fpecies of a Worm, that carries its cafe or cell about with it.

c The cell of a triangular form at its upper end.
d A nocturnal Butterfly or Moth, into which the faid Worm changes.
e A Fly, into which another fpecies of thefe Worms changes.
f A little Fly, into which the third part of the faid Worms was changed. I found fix or feven of thefe very minute Worms.

FIG. XXXV.

A pyramidal cell, formed by a Caterpillar that inhabits it, and moves about with it. This cell or tube is compofed of bits of wood, fo as to refemble a piece of cheque or mofaic work.

FIG. XXXVI.

A tube or cell formed of fand by a Sea-Worm.

TAB. XLVI.

The flow growths or accretions of the Frog, and Garden Clove-July-Flower, in which they refemble the infects.

The figures on the left hand fide exhibited.

No. I. The Frog's egg, or the Worm of the Frog, within its firft coat, or integument, refembling resembling a little globe or sphere, enclosed by another greater globe.

a The enclosed globe forming, as it were, the yolk of this egg.

b b The enclosing globe, resembling the white of the egg.

II. The Worm of the Frog divested in a manner, of its first coat.

c The coat removed to the hinder part of the Frog's Worm.

d The Frog's Worm rolled out from under the said coat.

e e e Its food, like the white of an egg surrounding it.

III. The Tadpole or Worm of the Frog grown bigger, and floating in the middle of its food.

f f f The food swimming, or floating in the water, like an expanded cloud.

g The head, breast, and abdomen, made up as it were in one globe or sphere.

h The tail.

IV The same Tadpole more grown, shewing its fore legs, which encrease by degrees as do likewise the hinder legs, but still under the skin.

i i The fore legs growing out by degrees.

V. The Nymph of the Frog, or the Tadpole sufficiently grown, and in a condition to become a Frog, as all the limbs of the Frog have acquired in it their due perfection, so that to appear in the form of a Frog, it need only cast its external skin.

k k The fore legs, which by degrees have acquired their perfection under the skin.

l l The hinder legs, which are likewise perfect, and project beyond the skin.

VI. The Frog itself, arrived at length at the state of a perfect animal, after passing through the various forms, of egg, Worm, and Nymph. It is not however, like insects, immediately fit for generation, but must wait some years to attain that degree of perfection.

m m Two vesicles growing near the eyes of this Frog, which shew it to be a male one.

The figures on the right hand represented.

No. The garden Clove-July-Flower in its first coat, in which state it is called seed.

A. A microscopical view of the seed itself, in which may be seen the cicatrix or scar of the naval string, by which it was fastened to the ovary, and received its nourishment.

II. The coat cast off by the said seed.

B. The seed itself, that lay enclosed within the said coat, of its natural size.

C. The same seed stripped of its coat, and magnified, so as to shew its little points and bivalved partition cleft, which divides the rest of the body into two parts,

III. The young germe of the Clove-July-Flower.

IV. The same germe unfolded into leaves.

V. The case, or as it were the gem or bud of the Clove-July-Flower, which may be considered as the real Nymph of the vegetable.

VI. The Clove-July-Flower itself broken from its gem or bud, and in a condition to produce seed.

T A B. XLVII.

F I G. I.

The genitals of the male Frog, viewed with the microscope.

a a The testicles. *b b b b* The loins.

c Some of the appendages of the testicles, consisting of oily or fatty bags.

d A single appendage of the same kind.

e Others divided into two branches.

f Blood vessels on the surface of the testicle.

g g Globular heads or ends of the seminal testiculary vessels

h Some testiculary vessels, consisting of two parts.

i i Divided parastatæ, or seminal vessels, by means of which the seed is forced from the testicles into the common vasa deferentia.

k k The manner in which these vessels run under the membrane that encloses the kidneys, and unite with the vas deferentia.

l l l l Vasa deferentia lying round the loins.

m m A rough draft of the arteries distributed through the kidneys.

n n Two singular and strange bodies seated at the kidneys, under the skin.

o o The place where the deferentia form on each side a single trunk.

p p Seminal vessels, or seed bags.

q q The straight gut, into which the vasa deferentia and seminal vesicles discharge themselves.

r The orifice, or end of the said parts.

s s The urinary bladder divided into two parts.

F I G. II.

All the foregoing parts, of their natural size.

F I G. III.

One of the ovaries, of its natural size.

a a Divisions, or natural ends of the ovary.

b A brass tube introduced into one of the little lobules of the ovary, in order to blow it up.

c c Eggs appearing through the membranes composing the ovary.

d One of the lobules of the ovary laid open, so as to afford a distinct view of the enclosed eggs.

F I G. IV.

The heart, liver, lungs, tubes, uterus, &c. in an impregnated female Frog.

a The skin wi͏h the sternum and its cartilage drawn back over the head, and fastened with a needle in that situation.

b The cavity, or hollow of the membranes, containing the heart, and formed under the breast

breaſt bone by the concretion of the peritoneum, and the ligament by which the liver is ſuſpended.
c c Natural openings of the tubes, growing againſt the membranes already taken notice of, which extend over the heart, and its pericardium.
d d That part of the tube which makes a great many beautiful windings and foldings.
e The blood veſſels of the tubes.
f f The extremities of the tubes, near or about the ſides of the uterus.
g g The uterus, conſiſting of two parts.
h The ſtraight gut in its natural ſituation.
i The urinary bladder, conſiſting of two parts, in its natural ſituation.
k The contracted ovary, in which there ſtill remains one perfect egg.
l Part of the left kindey, upon which the ovary lies, and at whoſe ſide lies the vein of the kidney.
Appendages of the ovary ſupplying it with oil.
n Two eggs floating freely in the belly, near the tubes
o An egg in the tube itſelf.
p The ſtomach contracted, in its natural ſituation.
q One of the tubes of the liver.
r The gall bladder.
s s The lungs; the left one contracted.
t t The auricle of the heart.
u u u Parts of the thorax and abdomen cut off.

FIG. V.

The manner of finding the eggs diſperſed in the Frog's belly, when in their paſſage through the tube into the uturus.

a Some little eggs in the ovary.
b b b Some eggs, ſcattered up and down the belly.
c Six eggs cloſe to the tube's mouth.
d d d Eggs in the tubes.
e An egg in the tube, near its mouth.
f f Some eggs, preſſing through the extremities of the tubes, into the utrus.
g The manner in which the eggs appear faintly through the uterus.
h The manner in which the eggs appear diſtinctly through the uterus, after it has been for ſome time expoſed to the open air.
i The extremity of the double uterus, which opens into the ſtraight gut, about an inch from the place where the tubes empty themſelves into the uterus.
k The origin or beginning of the great artery, with the auricle and heart.
l l Natural openings of the tubes.
m m The lungs in their natural ſituation, in part covering the tubes.

FIG. VI.

A microſcopical view of the fore legs or arms of the male Frog.

a The thick thumb.
b Black papillæ, with which it is covered.

TAB. XLVIII.

FIG. I. and II.

The manner in which the Frogs copulate.

a a The manner in which the male embraces the female, with his arms, and as it were folds his fingers between one another.
b b The manner in which the head of the male, lies over the head and between the eyes of the female.
c c The drum of the ear, covered only with the external ſkin.
d The manner in which the female ejects her eggs.
e The manner in which the male pours out its ſeed upon them.
f The manner in which the eggs flow together in a circular form.

FIG. III.

A microſcopical view of the ovary and its appendages.

a a Some eggs, *b* Larger eggs.
c d Eggs becoming imperceptible by degrees.
e Blood veſſels interwoven with the eggs
f A perfect egg, about to diſappear in the ſame manner

FIG. IV.

A cluſter of eggs magnified.

a a a Hollow membranes, or little membranes full of cavities, in which the eggs lie.
b b Blood veſſels belonging to the ſaid cluſter.
c c The main trunk of the blood veſſels.

No. 1. *to* 10.

The ſlow increaſe or growth of the eggs.

1 A Frog's egg newly depoſited.
2 Another, a day old.
3 Another, two days old.
4 Another, three days old, as expreſſed in four different drawings.
5 Another four days old.
6 The fœtus of the Frog, as it appeared the next day.
10 The ſame viewed on the tenth day from the laying of the egg.

FIG. V.

A microscopical view of the fœtus of the Frog in an egg newly deposited, and divested of its white.

a a A furrow in the middle of the Frog's body.
b b Remains, or rather rudiment, of a yellow spot, which appears in the skin of these creatures, even before they are hatched.

FIG. VI.

The same fœtus broken into two parts.

a A protuberance in form of a crescent, visible on the internal surface of one of the sides; in this place the furrow penetrates to a considerable depth.
b A little hole or cavity in form of a crescent, serving to receive the foregoing protuberance.
c c The place where the furrow is very shallow.
d d The surface of the fraction, shewing the Frog's body to consist of globular, or spherical grains or particles.

FIG. VII.

A microscopical view of the young Frog, within its chorion and amnion.

a A side view of the Allantoies, with the chorion and amnion which entirely enclose the fœtus.
b The furrows already taken notice of.
c Superficial clefts of the yellow spot, observable in the Frog's egg.

FIG. VIII.

The same parts, but in another situation.

a The coat, called the allantoies dilated.

FIG. IX.

Another representation of the same parts.

a The allantoies or coat, stretched out into the shape of a pear.

FIG. X.

The same parts again, with the foregoing coat extended to its greatest size and bulk.

FIG. XI.

The fœtus of the Frog, as it appears fourteen days after the laying of the egg.

FIG. XII.

A microscopical view of the same fœtus.

a a The eyes. *b* Its wide mouth.
c c Fimbricated appendages, which in process of time are taken in by the body, where they constitute the gills.
d The extremity of the extius of the intestine, which forms some windings and protuberances in the belly.
e e The tail, of a fleshy substance in the middle, but membranaceous at the edges.
f The extremity of the muscular and cartilaginous part of the tail.

FIG. XIII.

The fœtus of a Frog, thirty-six days after the laying of the egg, exhibing very distinctly its head, two hinder legs and tail.

a The aperture or opening of the mouth.
b The hinder legs and tail.

TAB. XLIX.

FIG. I.

The fœtus of the Frog represented by Fig. XIII. of the last Table, dissected, and viewed with a microscope.

a a The lower jaw-bone, of a black horny substance, and furnished with teeth.
b The upper jaw-bone.
c c White papillæ surrounding the mouth.
d d A portion of the protuberant eyes.
e e Four rows of gills on each side.
f f The lungs, one of which is inflated, the other collapsed.
g The heart. *h* Its auricle.
i The liver and vena cava.
k The gullet. *l* The gall bladder.
m The winding of the gullet about the liver.
n Part of the mesentery, with its blood vessels.
o The stomach in the beginning of its growth.
p The pancreas in its natural situation.
q The small gut.
r r Very beautiful double foldings of the intestines.
s The straight gut. *t* The podex.
u u The two hinder legs, which grow beyond, or on the outside of the body.
x x The fore legs, which lay hid under the skin. *y y y* Muscles of the tail.
z z The membranaceous skin of the tail.

FIG. II.

The manner in which the Tadpole casts it skin.

a The small opening of the mouth, in the skin cast by the Tadpole.
b The wide mouth of the Frog.
c c The two fore legs, which heretofore lay hid in the breast, under the skin, now divested of it. See Tab. XLVI. No. V. letters *k k*.
d d The two hinder legs on the point of dropping their skins.
e e Pulmonary vesicles, which nature has bestowed on the male only.

f f Two

f f Two thick thumbs, proper likewise to the male.

FIG. III.

The Frog's arteries.

a The heart.
b The auricle, over which lies the origin of the great artery that issues from the Frog's heart.
c One of the two main trunks of the great artery, which is like the subclavian vein, and runs towards the right side of the thorax.
d The other main ascending trunk, running to the left side.
e e Arteries of the lungs, which they only serve to nourish. I have here exhibited three branches of them, cut off.
f f Two minute arteries, issuing from the lungs, and running towards the parts of the mouth.
g g Two arteries, each of which swells into two knots.
h h Two very considerable branches of the arteries, which arise from the ascending trunks of the great artery, then take a circular turn, and at length unite in the loins.
i i The axillary arteries.
k k The carotide arteries.
l l The arteries of the vertebræ.
m That of the mesentery.
n n That of the loins.
o o Those of the testicles, and ovary.
p Those of the kidneys.
q q The iliac branches.

FIG. IV.

Veins of the Frog.

a a The upper trunks of the vena cava.
b The place where the arteries are cut away.
c c The place where the pulmonary veins are likewise cut away.
d d Veins running to the parts of the mouth.
e e Others running to the head.
f f Two veins, running to the muscles of the fore legs.
g g Axillary veins.
h h Two considerable branches, which run into the ilia under the skin.
i i The trunk of the vena cava, on the back.
k k The vena cava in the liver.
l The vein of the mesentery.
m The emulgent or kidney veins.
n n The iliac.
o o The epigastric vein, running double at its origin.

FIG. V.

The motion of the muscles in a Frog.

a a Two tendons of a muscle, held by the fingers.
b The dependent nerve of it, irritated; by means of which the muscle contracts itself, and so draws towards itself, the two hands holding the tendons.

FIG. VI.

The manner in which the thickness of the muscle increases, during the contraction of the muscle.

a A glass tube, through which the muscle is passed.
b b Two pins run through the tendons of the muscles.
c The irritated nerve, by which it comes to pass that the pins *b b* are forced from their places towards *d d*, and that
e The muscle, in consequence of its contraction, fills the middle of the tube.

FIG. VII.

The manner in which the heart, during its contractionss takes up less room, and lessens in bulk.

a The heart, contracting itself within a syphon or glass tube, upon whose piston it lies.
b b A glass tube.
c A drop of water, adhering to the inside of the tube, which drop descends while the heart contracts itself.
d The part of the tube, shewing how low the drop of water *c* falls at that time.

FIG. VIII.

The manner in which the muscle, at the time of its contraction, comes to occupy a smaller space.

a The glass tube, or syphon
b The muscle.
c A silver wire with a ring in it, through which the nerve passes.
d A brass wire, with a ring on the upper end of it, through which the silver wire passes.
e A drop of water in the glass tube.
f The hand that irritates the nerve, in consequence of which irritation the drop on the muscle, contracting itself, descends a little.

FIG. IX.

The same experiment, shewn after another manner.

a The glass tube.
b A little hole bored in the tube.
c The nerve stretched through the said hole.

TAB. L.

The history of the Cuttle-Fish.

FIG. I.

The external parts or limbs of the Cuttle-Fish, laid

laid flat on its belly, ſomewhat leſs than nature.

a a The two thickeſt and broadeſt of the Cuttle-Fiſh's eight legs.
b White furrows on the purple ground or ſkin of the legs.
c c c The acetabula, or hollows like ſaucers, with their ſtalks, pediments or muſcles, of which there is a ſurpriſing number diſtributed all over the eight legs.
d d Origins of the arms of the creature, in their natural ſituation.
f f f The looſe membranaceous and muſcular ſkin of the eight legs, with which ſkin the acetabula are covered, when the Cuttle-Fiſh faſtens itſelf to any place.
g g Places of the legs where the acetabula are very ſmall, but have notwithſtanding the benefit of the ſkin.
h h A more diſtinct view of the ſaid muſcular ſkin near the extremities of the arms; and likewiſe of the manner in which it ſerves to cover the acetabula.
i The Fiſh's ſnout, or beak, formed like that of a Parrot.
k Fleſh, which ſurrounds the ſnout or beak, like lips or gums.
l l The eyes, of an extraordinary ſize.
m m The tranſparent cover of the eyes, or eye-lids.
n The prominent point of the back.
o o o o The ſoft and muſcular part of the Cuttle-Fiſh, on each ſide of its back.
p The place, lower down, where it is divided into a right and left ſide.

FIG. II.

The conſtruction of the acetabula, the muſcles and rings of their natural ſize.

1 A muſcle in the centre of the acetabulum, as likewiſe the manner in which this part is entirely compoſed of muſcular fibres. On the upper part may be ſeen the black edge of of a horny bone, in form of a ring, of conſiderable ſervice in the conſtruction of this organ.
2 The internal cavity of the acetabulum, its fibrous and muſcular ſtructure, as likewiſe the black edge of the ring, juſt now mentioned. Lower down is to be ſeen that part of the muſcle, which ſerves to dilate the acetabulum.
3 The ring, already exhibited by its ſelf, placed on its ſide.
4 A front view of the ſaid ring.
5 Part of the ſaid ring cut off.

FIG. III.

The conſtruction of the ſnout or beak, of its natural ſize.

a a The wings of a horny bone, compoſing the lower part of the beak or ſnout.
b b The place where the beak or ſnout is bent upon itſelf, ſo as to acquire both firmneſs and thickneſs.
c The place where the ſaid bent back part of the ſnout or beak turns, and runs forward again, and forms a hollow cavity.
d The upper part of the ſnout or beak, which differs very little from the lower in point of conſtruction or ſhape.
e e Its internal hollow, containing the tongue.

FIG. IV.

The tongue, and ſalival ducts, of their natural ſize.

a A natural bending, or inflection about the cartilaginous bones of the tongue.
b The muſcular fleſh of the tongue, of a ſpungy or fungous ſubſtance.
c The mouth of the ſalival duct, in the muſcular part of the tongue.
d The ſalival duct itſelf.
e e Two glands, from which the ſalival duct takes its origin.
f f Some of the muſcles belonging to the tongue.

FIG. V.

The tongue by itſelf, of its natural ſize.

a The unequal membrane of the tongue.
b Seven cartilaginous bones of the tongue, ſeparated from each other at their extremities.

FIG. VI.

A microſcopical view of part of the cartilaginous bones of the tongue.

a Cartilaginous papillæ, ſituated on the ſaid bones.

FIG. VII.

A microſcopical view of the tongue, inverted.

a a Part of the root of the tongue, where its bones appear through the microſcope, in form of a regular piece of net-work.

TAB. LI.

FIG. I.

The internal parts of the Cuttle-Fiſh, that may be ſeen, without any diſſection, by juſt removing the looſe muſcular covering of the belly.

a a The muſcular covering of the breaſt and belly, cut off.
b b The place on the declivity of the belly, where the ſaid muſcular fleſh was cut off.
c The place near the tail, treated in the ſame manner.

d The

d The lower part of the common excretory bag like an inverted funnel.
e The upper part of the faid bag, narrower.
f f Two oval hollow parts, united to the excretory bag.
g g Two confiderable prominencies or papillæ, adhering to the loofe mufcular part of the abdomen. Thefe prominences fill up, while the creature lives, the hollow parts juft now mentioned.
h h Two oblong and ftraight mufcles, which ferve to move the acetabula, that are, as it were, fupported by them towards the papillæ, and draw them back again.
i i The gills, and their blood-veffels, fituated at each fide of the abdomen, and at a great diftance afunder.
k Divifions of the blood-veffels in the lamellæ, or plates of the gills, extended on the infide to their roots.
l l The place where the lamellæ of the gills terminate in a ligament, which ligament might very eafily be taken for a blood-veffel.
m The fame more diftinctly exhibited; as likewife a view of the divifions of the blood-veffels in the lamellæ of the gills.
n A tranfparent part, called *mutis.*
o The extremity of the ftraight gut, which floats in the abdomen, like a hollow tube.
p The tranfparent ink--bag, which likewife difcharges itfelf into the abdomen.
q q Two tubular apertures, or openings, beneath the ftraight gut, and near it, by which the feminal matter is emitted.
r The place where there lie deeper, under the other parts, the veffels in which the feminal matter is prepared.
s The tranfparent ftomach.
t A tranfparent particle, in form of a heart, belonging to the fpermatic parts.
u The extremity of the vafa differentia of the tefticle, floating likewife freely in the abdomen.
x The tranfparent tefticle.
y Some arteries, which run to the mufular parts of the fkin. Their fellows are to be feen on the other fide of the body.
z Tranfparent nerves, which appear in great numbers through the fkin, both there, and and at the other fide.
α The mufcular circle of the mouth.
β β The arms, cut off.
γ γ The order obferved by the acetabula during the contraction of the mufcles.
δ δ The internal conftruction of the broadeft and largeft of the eight legs.
ε ε The two eyes.

FIG. II.

A very diftinct view of the mufcles of the fmalleft acetabula, in their natural fituation and fize, as they appear on the extremity of one of the arms, feparated from the reft.

a The conftruction and fituation of the mufcles of the acetabula.
b The manner in which the acetabula are united with their mufcles.
c d The place where the mufcles are fhorteft and fmalleft, being where the rows of acetabula begin and terminate.

FIG. III. and IV.

The body, called mutis, *a little lefs than nature.*

a a Its upper part, which is very thick, and may be divided on each fide into two lobes.
b b Its obtufe appendages, in which the lower part of it terminates.
c c Two arteries, iffuing from the great artery, and running to or fupplying the right and left fides of the mutis.
d A membrane feparated, and turned back from the mutis, in order to give a view of it internal veffels.
e The courfe of the veffels, exhibited apart.
f f A granulated fubftance, of which the mutis is principally compofed.

FIG. V.

The gullet, ftomach, ftraight gut, pancreas, and excretory duct of the Ink.

a The jaws.
b b Salival glands, in their natural fituation. The gullet runs lightly over thefe glands, in its way from the jaws to the ftomach.
c The ftomach.
d The blood-veffels of the ftomach.
e The ftraight gut.
f The pancreas, beautifully wound into a fpiral form.
g The bladder, ferving to force out the ink.
h The duct of the ink from the faid organ to the extremity of the ftraight gut.
i Th blood-veffels of the ink-bladder or bag.
k k k A glandulous body, whofe ufe is not yet difcovered.

FIG. VI.

A piece of the Cuttle-Fifh's bone.

a A great number of little lamellæ or plates, compofing the bone. The uppermoft are the largeft, and lie clofeft to each other.
b The hard crufty covering of this bone. The lamellæ or plates that are neareft to this cruft are the fhorteft, and likewife at the greateft diftance afunder, fo as to afford a more fatisfactory view of the little columns that fupport them, one above another.

FIG. VII.

A microfcopical view of two of the lamellæ, or plates, and their interjacent columns.

c The beautiful order in which the columns are placed between the teſtaceous ſhelly lamellæ or plates.

d The firſt or upper lamella or plate, in which appear the marks of the columns, broken away from it.

e The lower or ſecond plate.

f Some tranſverſal fibres of a ſhelly ſubſtance, which bind the columns together, and thereby add conſiderably to their firmneſs.

FIG. VIII.

Some of the plates, juſt now exhibited, removed from the columns that ſupported them.

g Their hollow tubular conſtruction, in conſequence of which they muſt naturally contain a portion of air, and of courſe the bone can ſwim on the ſurface of the water.

FIG. IX.

The tail of the Cuttle-Fiſh's bone, drawn after nature.

h A ſharp point, thro' which the Cuttle-Fiſh's bone grows out.

i i The membranaceous parts on each ſide.

k The place where the piece of bone, under our conſideration, was broken off from the reſt of it, ſhewing ſome beautiful globular eminences, which firſt hardened into a ſtony bone above the reſt of the ſurface.

TAB. LII.

FIG. I.

The heart and arteries of the Cuttle-Fiſh, of their natural ſize.

a The heart.

b b The double auricle of the heart.

c c Part of the largeſt blood-veſſels belonging to the gills, from which the auricles are ſeparated. *d* The great artery.

e e Its two branches, running to the body of the mutis, while others proceed further.

f Arteries extended to the baſe, or root of the brain, where they are afterwards diſtributed.

g g Two blood-veſſels, iſſuing from a lower part of the heart. They are full of veins.

FIG. II. III. and IV.

The brain, nerves, and eyes, of their natural ſize.

a The brain.

b Fat lying near the brain, repreſented by dots.

c c The optic nerves, whoſe origens are likewiſe inveſted with fat.

d d Knotty dilatations of the optic nerves.

e e e e Nerves ſent in great numbers from the ſaid nodules or knots to the eyes.

f A blood-veſſel, that interſects the nerves running to the eyes.

g A great many little nervous fibres in the choroides of the eye.

h The place where the ſaid coat converges a little more in form of a globe about the cryſtalline lens, and thereby forms the iris of the eye.

i A portion of the cryſtalline lens, projecting beyond the eye.

FIG. III.

k The cover of the pupil, on that ſide where I cut it off from the eye.

l That ſide of the ſaid cover, which floats freely in the aqueous humour.

FIG. IV.

m The manner in which the cryſtalline lens is divided to a great depth by the ciliary ligament.

FIG. II.

11 22 23 Three pair of nerves iſſuing from the brain, the middlemoſt of which is beautifully dilated into a nodule.

n All theſe nerves are diſtributed amongſt the fore parts of the head.

o o Cartilages encloſing the brain.

p p Cartaliginous expanſions, in which the muſcles of the legs are placed, and in the middle of which the head and ſnout, or beak of the Cuttle-Fiſh, is placed.

q q Two ſtrong nerves, which iſſue from the bottom or root of the brain on its hinder part.

r r Two nodules, which theſe nerves form in the breaſt, and from which great numbers of nerves run to the lower parts of the Cuttle-Fiſh's body.

FIG. V. and VI.

The teſticle and its parts, of their natural dimenſions, viewed on each ſide.

a Some little white bodies, which I found hanging in this creature on the outſide of the vas differens.

b The pointed extremity of the teſticle.

c The corpus variciforme of the teſticle.

d Its extremity, as far as I have as yet been able to trace it.

e The place where the paraſtatæ are moſt ample and ſpacious, as may be ſeen in the teſticle, turned upon its other ſide.

FIG. VI.

f Some other minute extracted from the teſticles, which was full of them. Theſe parts are all looſe in the hinder part, without the leaſt faſtening.

g Some

g Some fine filaments, in which the faid minute parts terminate on their fore ends, and by means of which they are there connected together.
h The manner in which a white fubftance, that curls itfelf in a ferpentine form, iffues from the faid minute parts.

FIG. V.

i i The manner in which thefe white minute parts appear thro' the tefticle, and wind themfelves in a ferpentine manner, while as yet enclofed in it.

FIG. VII.

A microfcopical view of one of thefe minute parts.

a Its hinder part, loofe and tranfparent.
b A white fubftance enclofed in the faid part, and which is forced out of it by the water that penetrates it.
c Places where it is tranfparent at each end.
d Beautiful windings of the fame on its fore extremity.
e e Its fine, delicate, or flender filament, which hardens in the open air like the Silk-Worm's thread.

FIG. VIII.

Two pair of glandular bodies, belonging to the feminal veffels, of their natural Size.

a a The firft pair of thefe white bodies, cut off from the gills.
b b The fecond pair of gladular bodies of a gray colour, in other refpects like the firft pair, with which they are connected by means of two glandular tubes.
c c A glandular body fituated between the two pair juft defcribed.
d d Some tender membranes, which bind together the faid body and its lobules.

FIG. IX.

A third particle belonging to the feminal veffels, of its natural fize.

a Its figure on the upper part, where it is pretty flat.
b Its figure on the lower part, where it is fomewhat fharp, with a divifion in the middle, that gives it in fome meafure the refemblance of a heart.

FIG. X.

The genitals of the female of their natural fize.

a The ftraight gut.
b The duct of the organ ferving to prefs out the ink.
c The ink-bag itfelf.
d d The ovary.
e The duct by which the eggs are difcharged.
f Three eggs. *g g* Two glandular bodies.
h A peculiar part containing a reddifh humour.
i i The gills in their natural fituation.

TAB. LIII.

The feeds of the Fern.

FIG. I.

Part of a Fern leaf, with its tubercles.

a a An indented or jagged leaf of the Male Fern of Dodoneus, refembling the feather of a bird.
b b Tubercles of a Fern leaf compofed of fome leaves, and a great many little pods which contain the real feed of the plant.

FIG. II.

Five of the fame kind of pods of their natural fize, and viewed different ways.

c c c Three pods with fingle ftalks.
d One with a double Stalk.
e e e The place where the ftalk furrounds or girds the pod, as it were like a twifted cord in form of a crown.
f f The manner in which the pod fwells beyond the faid twifted cord on each fide of it.
g A pod placed in the center of the furrounding cord; as likewife the place where the pod firft begins to open.
h h The cord reduced to a ftraight line by fome elaftic power.
i i i i The pod burft in two, fo that the parts now confidered in themfelves form as it were four hollow cups.
l The membrane of the pod broke open, and turned back upon the coronal cord of the ftalk that furrounded the pod, fo as to afford a view of the enclofed feeds in their natural fituation. But it is by great chance that a pod opened in this regular manner can be met with.

FIG. III.

The feed.

k Five out of forty-one feeds, that I found in one pod, magnified to a very great degree.

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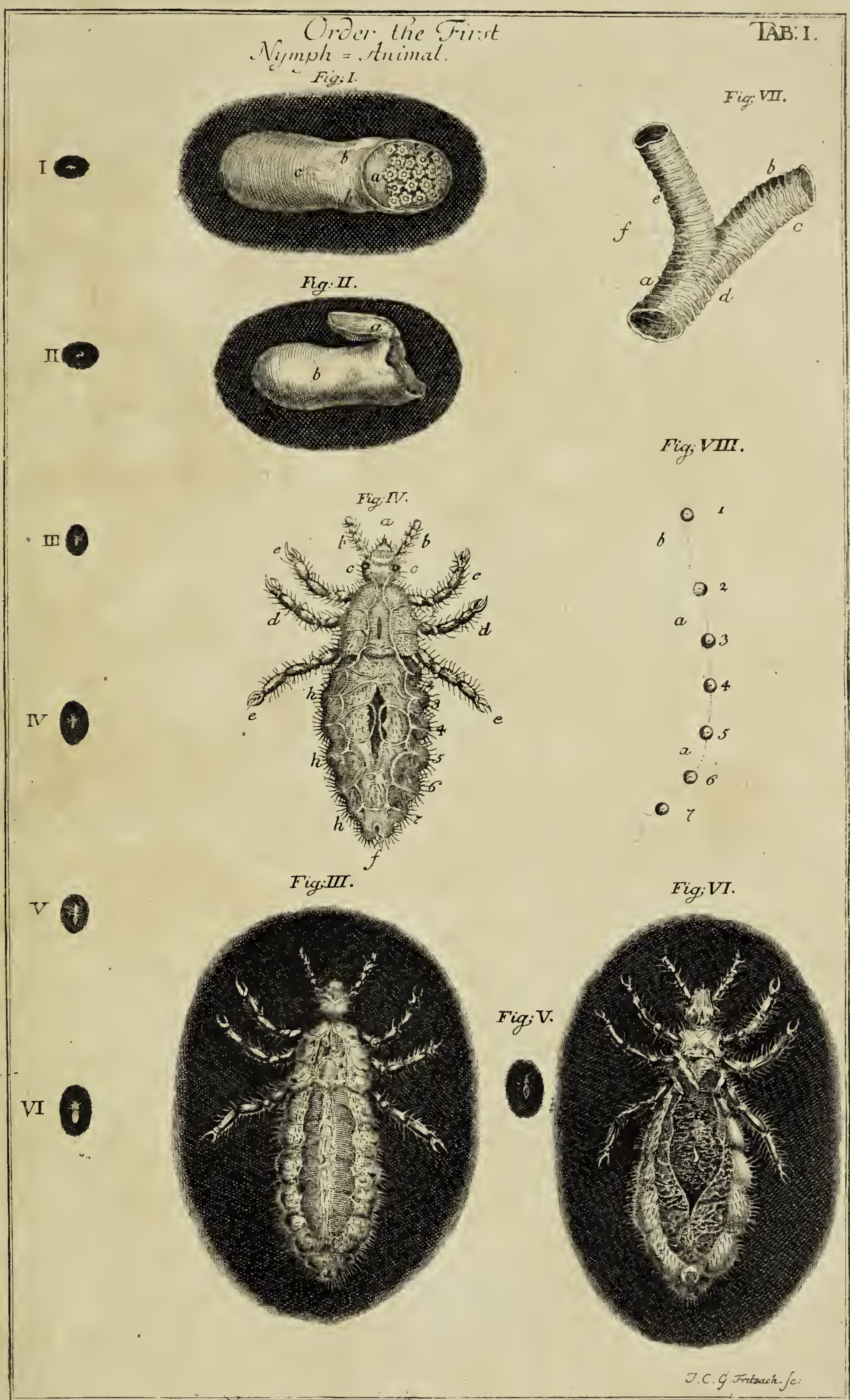
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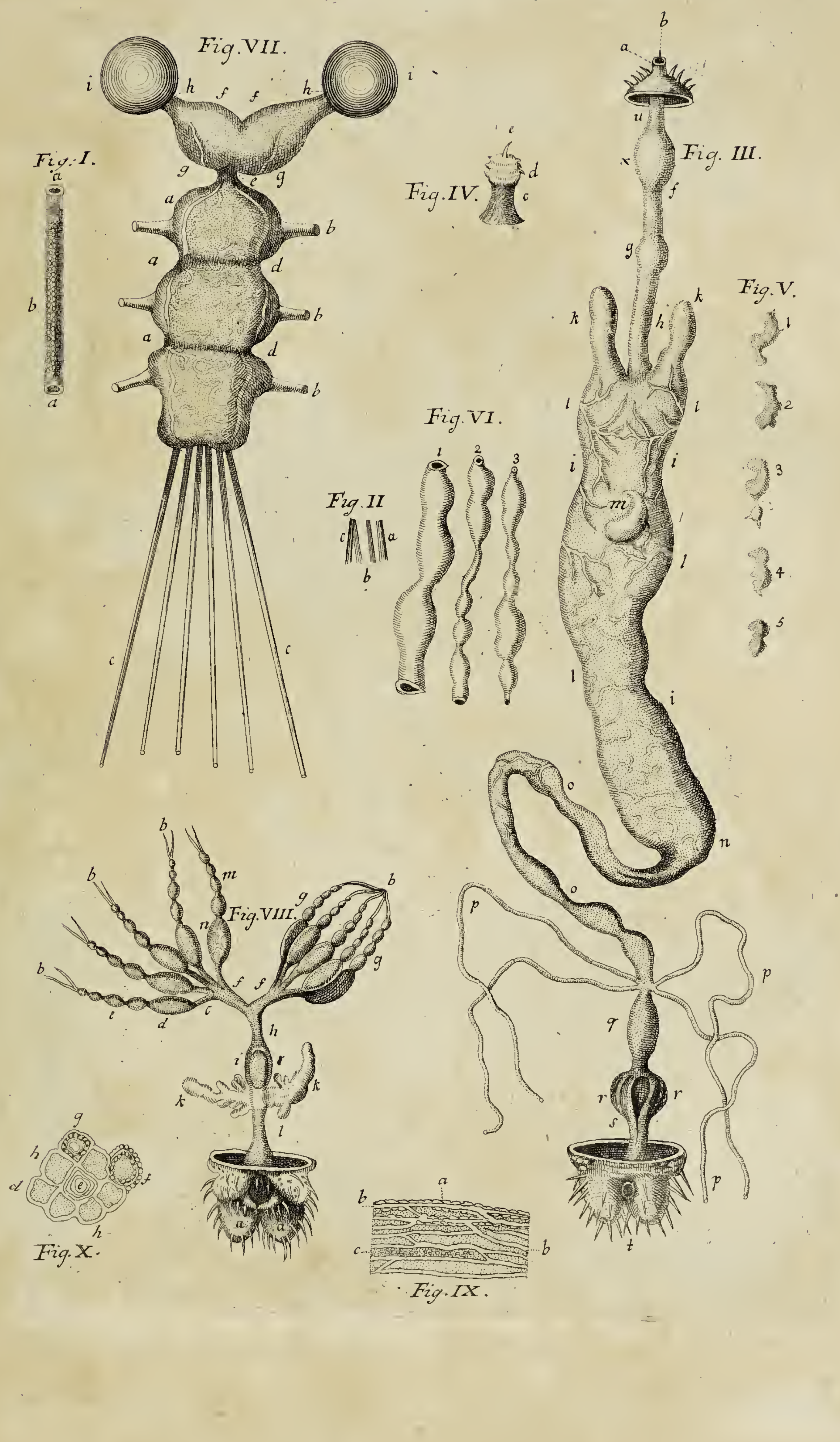
J. C. G. Fritzsch. sc.

TAB. II.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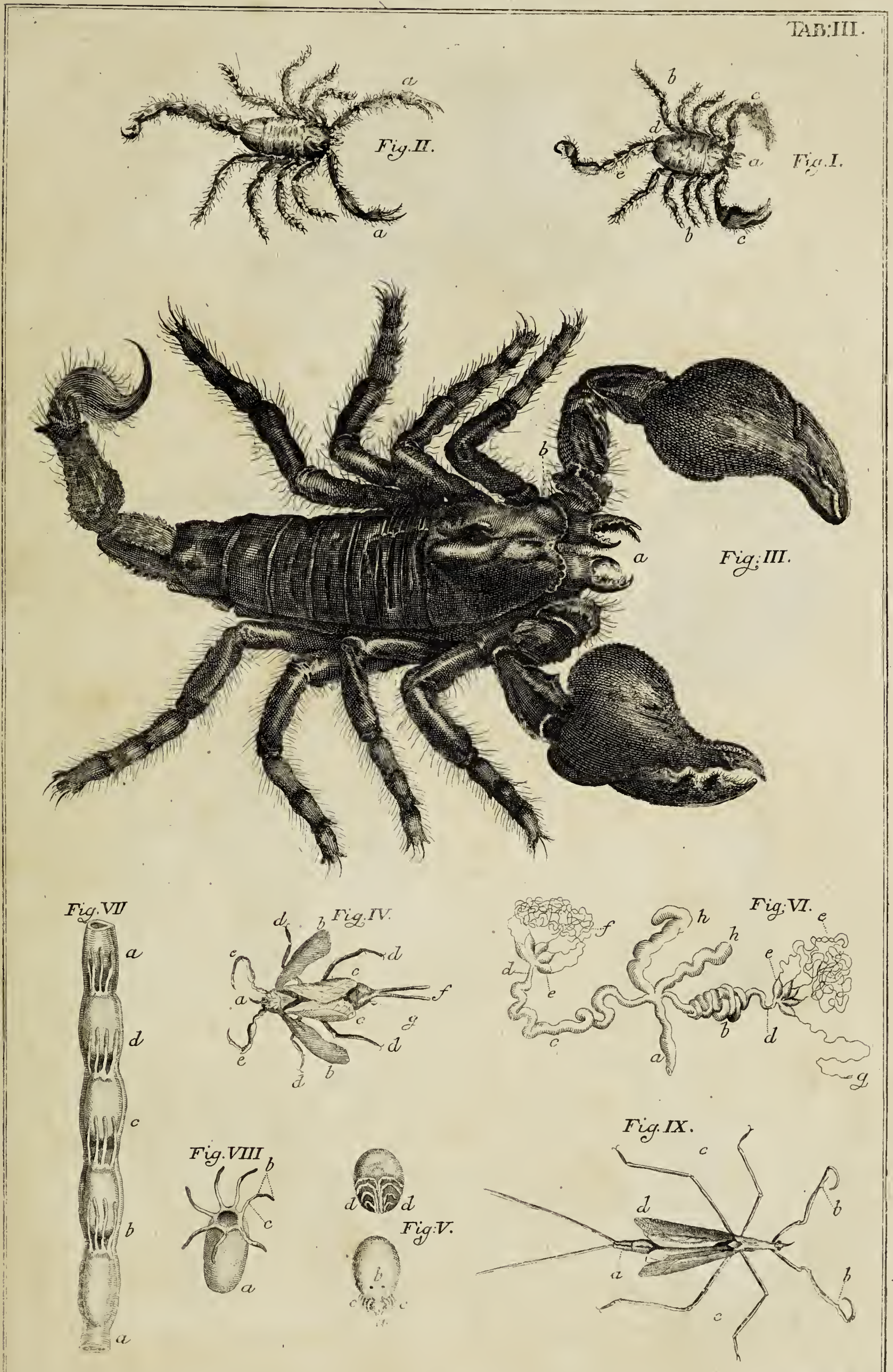
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Fig.VIII
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J.C.G. Fritsch f.

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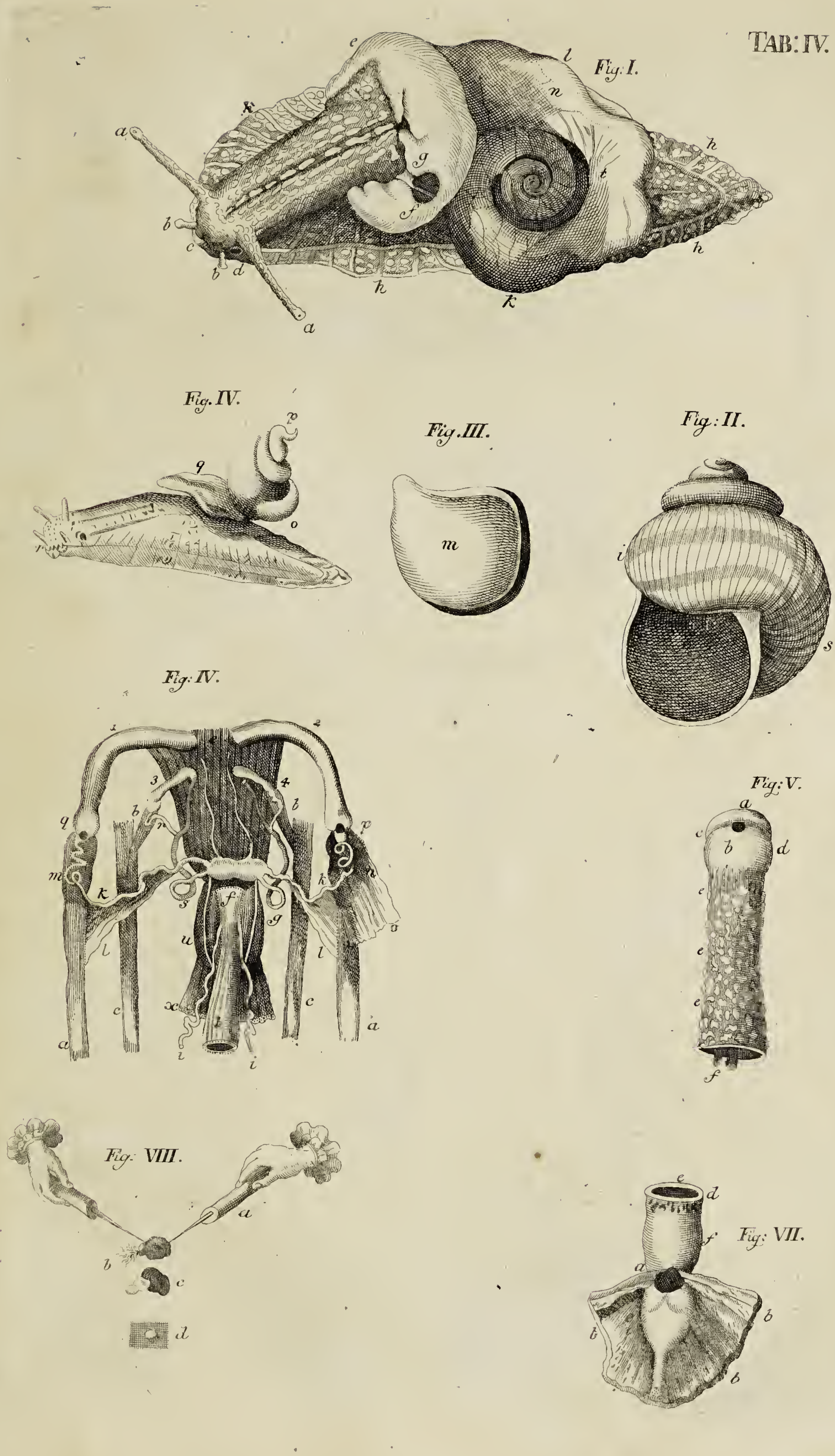

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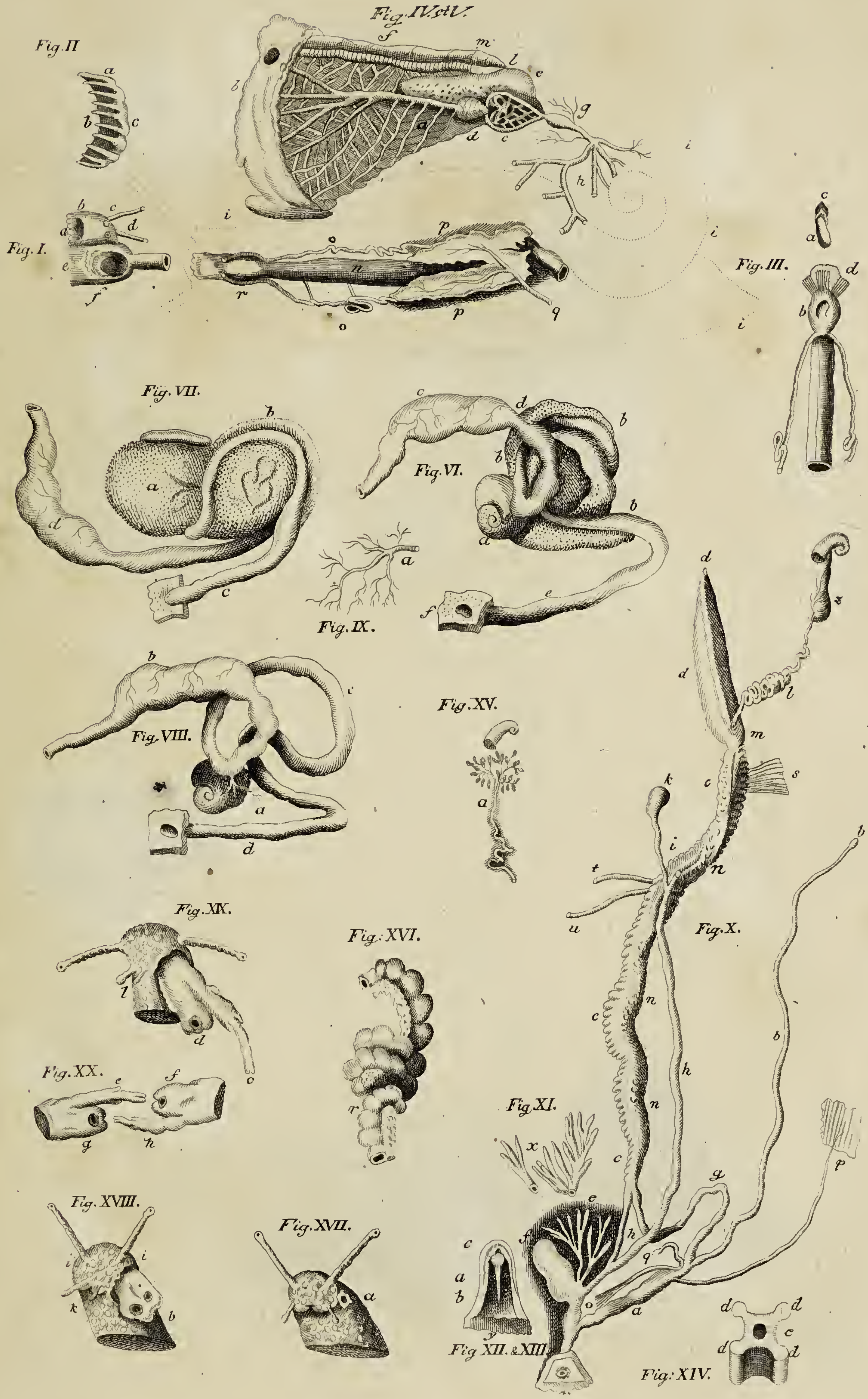
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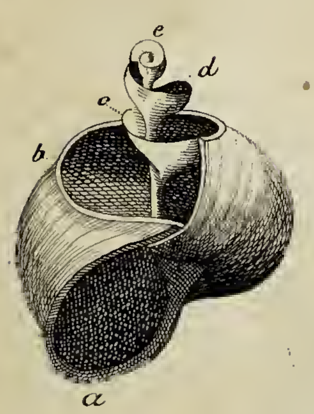

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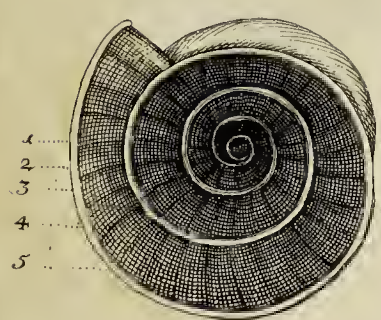

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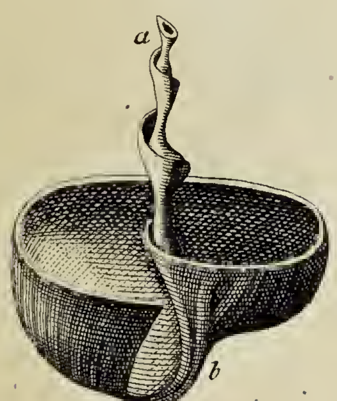

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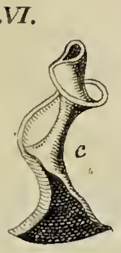

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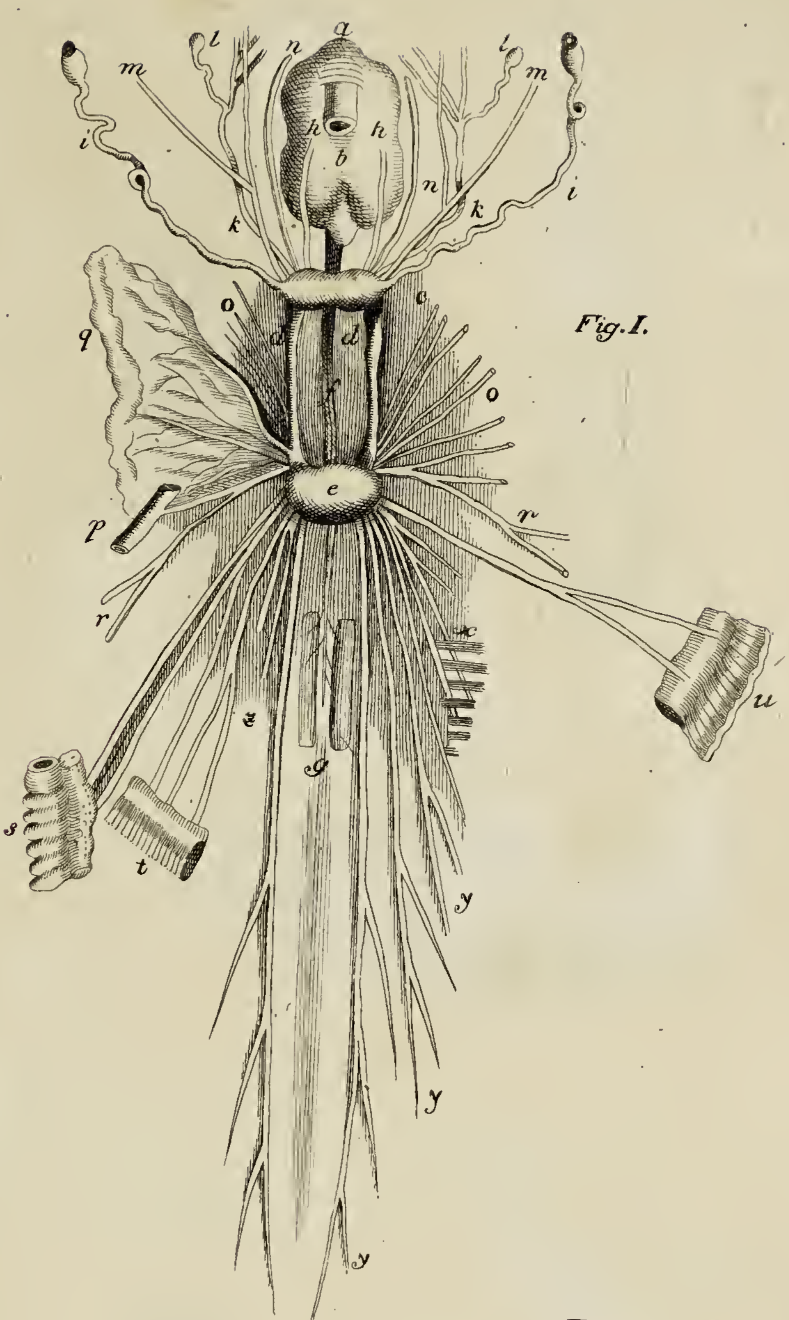

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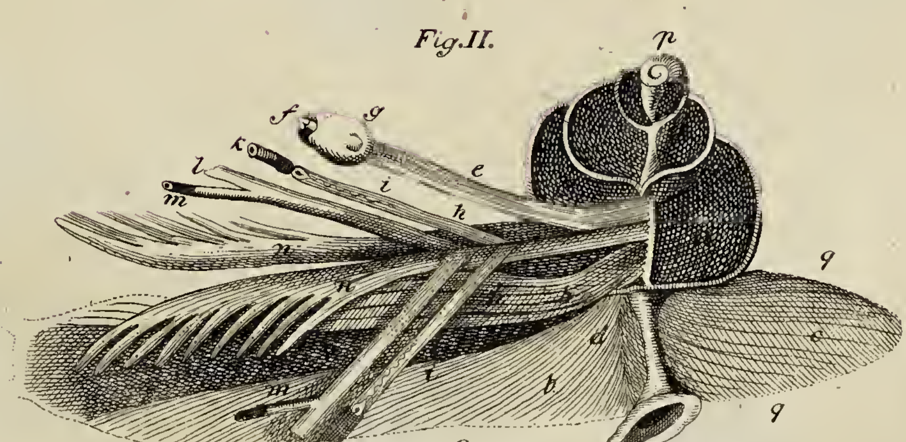

TAB.VII.


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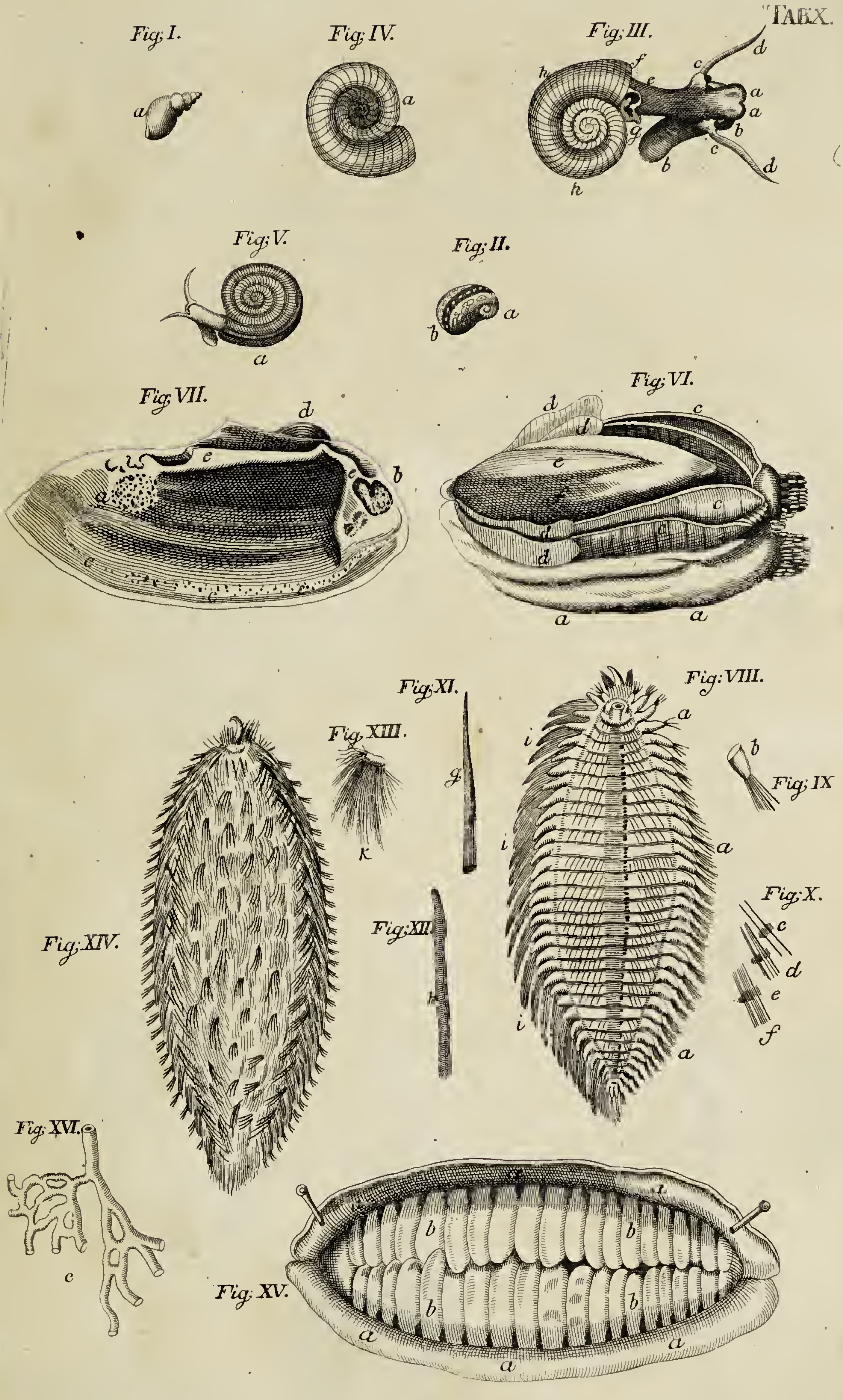
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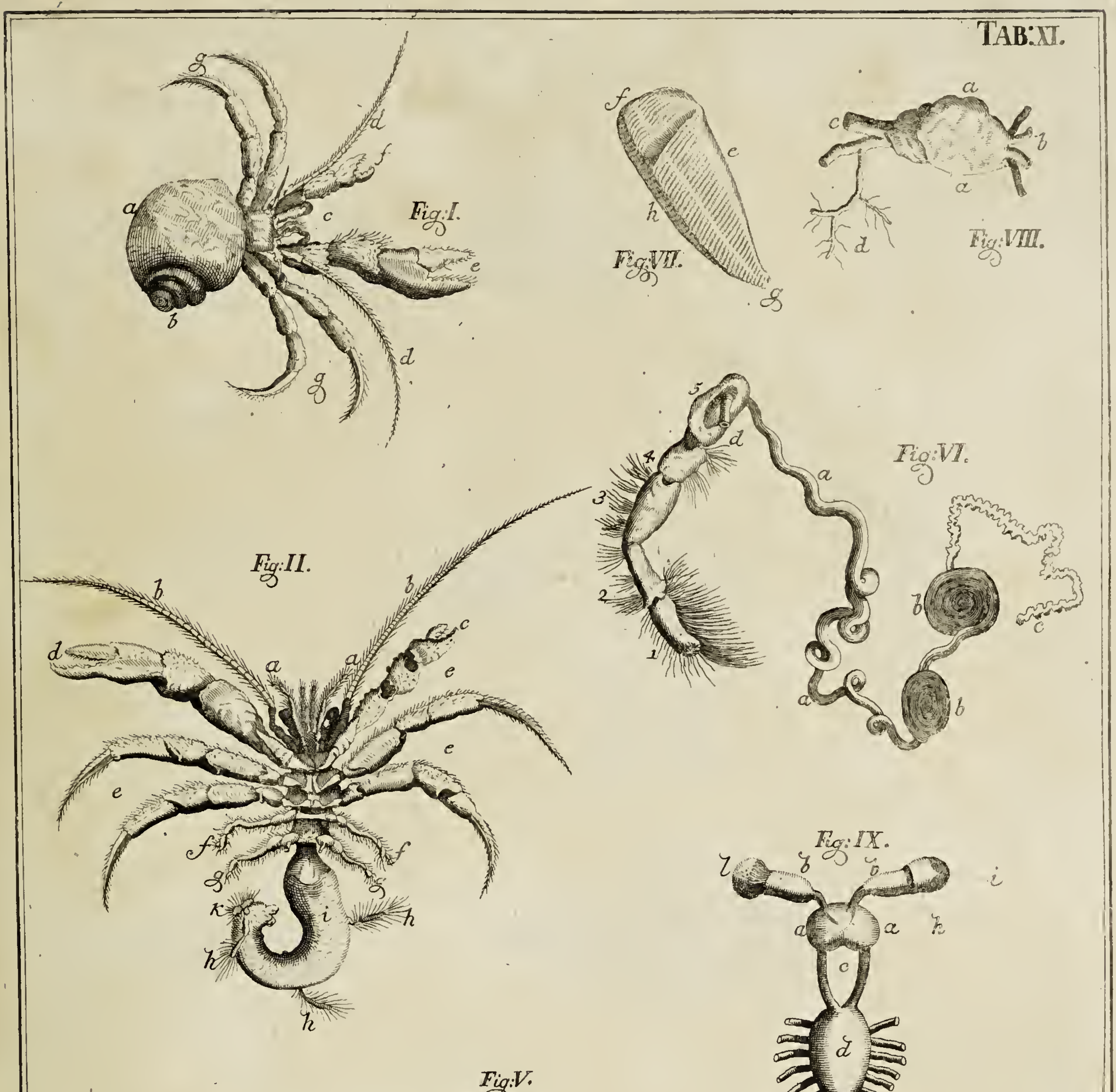
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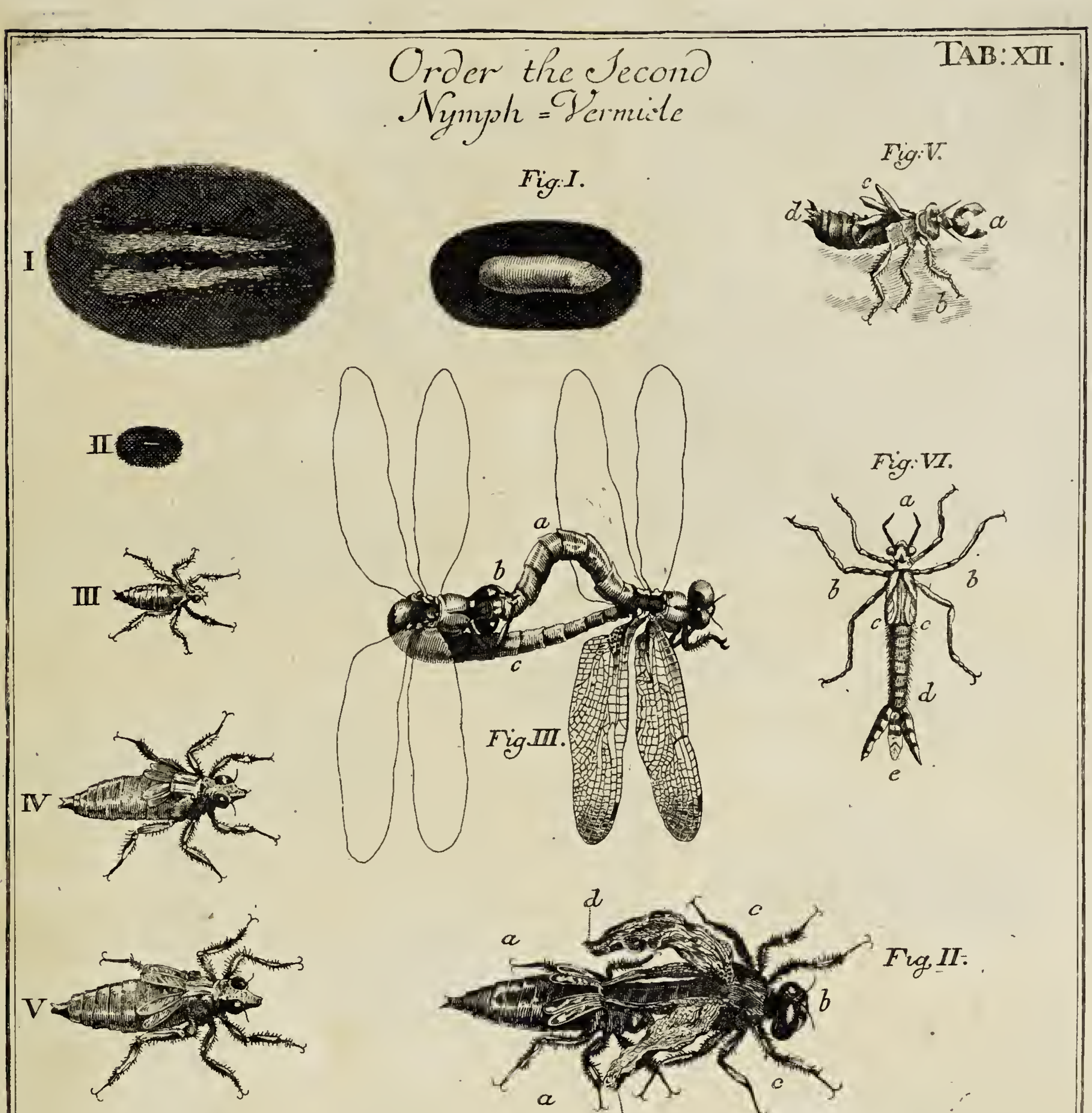
J.C.G. Fritzsch sc. Lipsiae


Order the Second
Nymph = Vermicle
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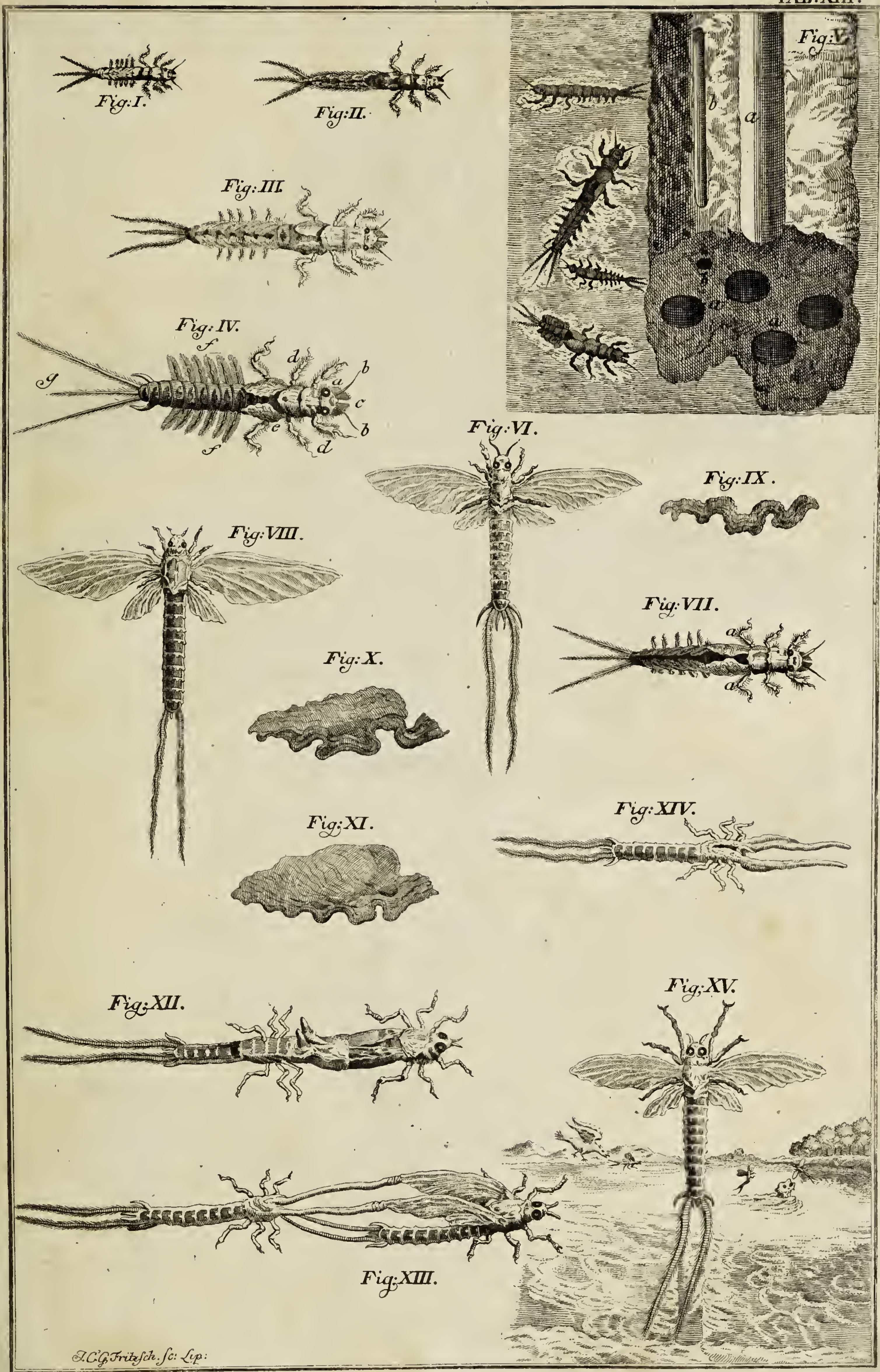
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J.C.G.Fritzsch.sc: Lip:


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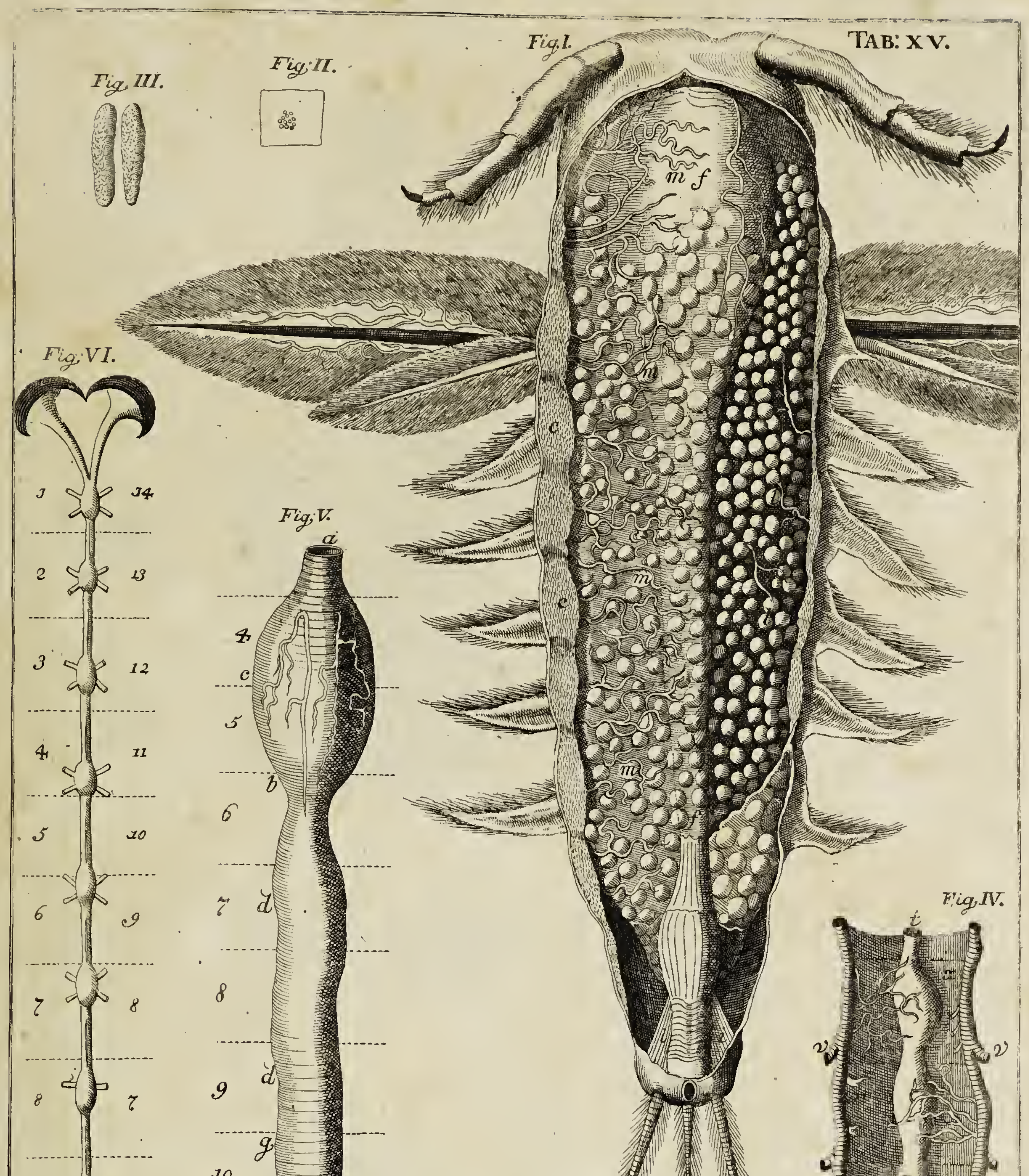
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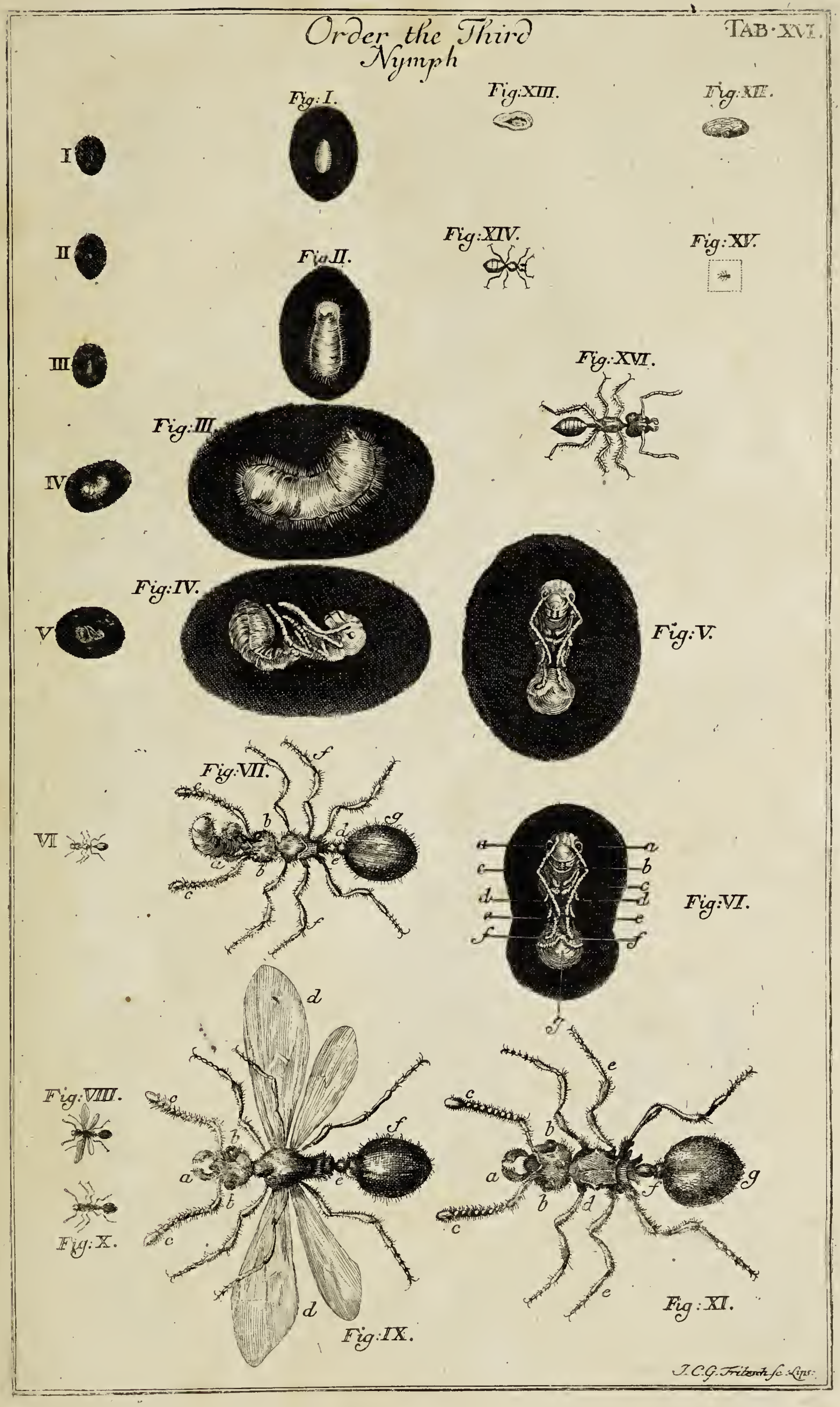
J. C. G. Fritsch sc.



Order the Third
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J.C.G. Fritzsch sc. Lips.

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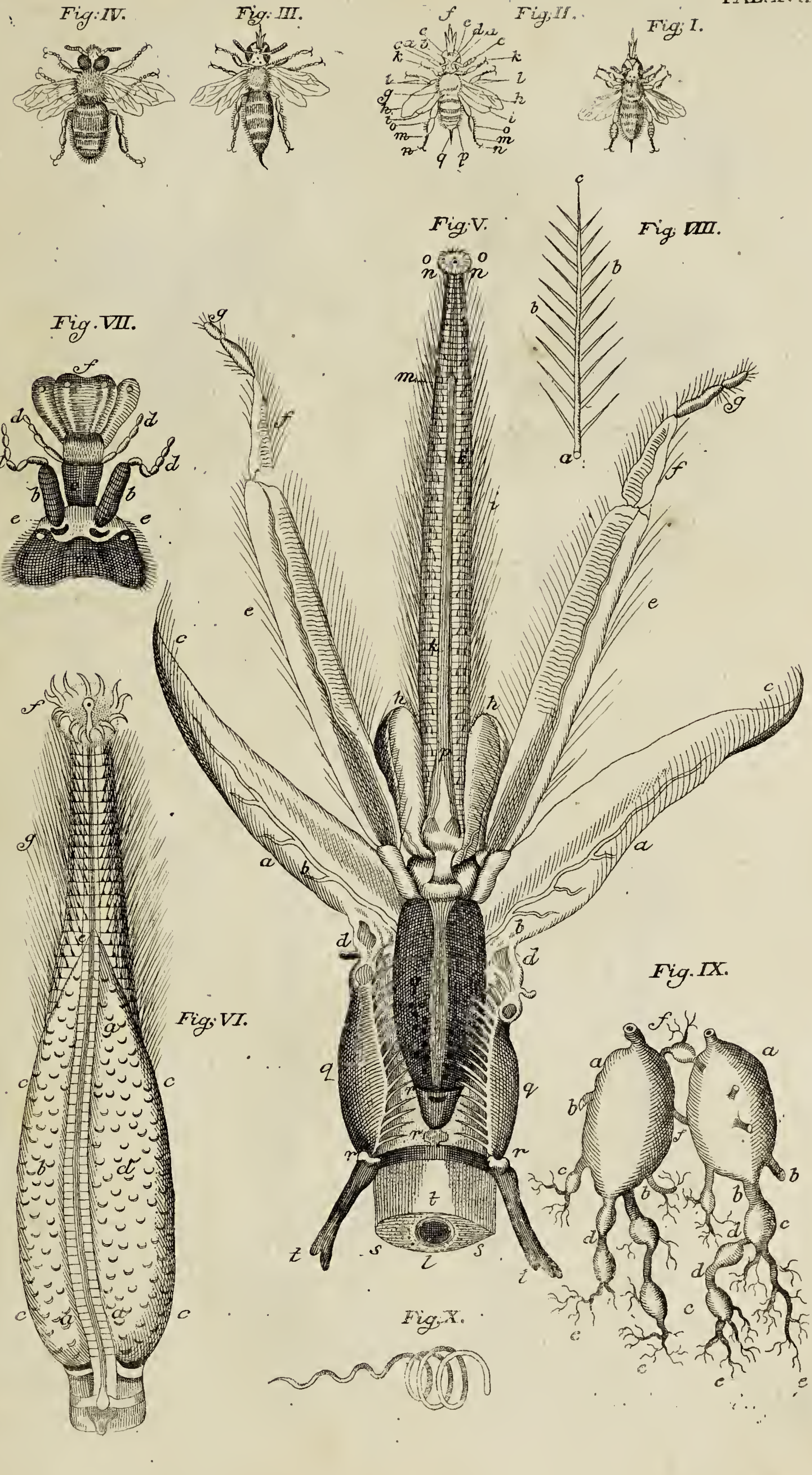

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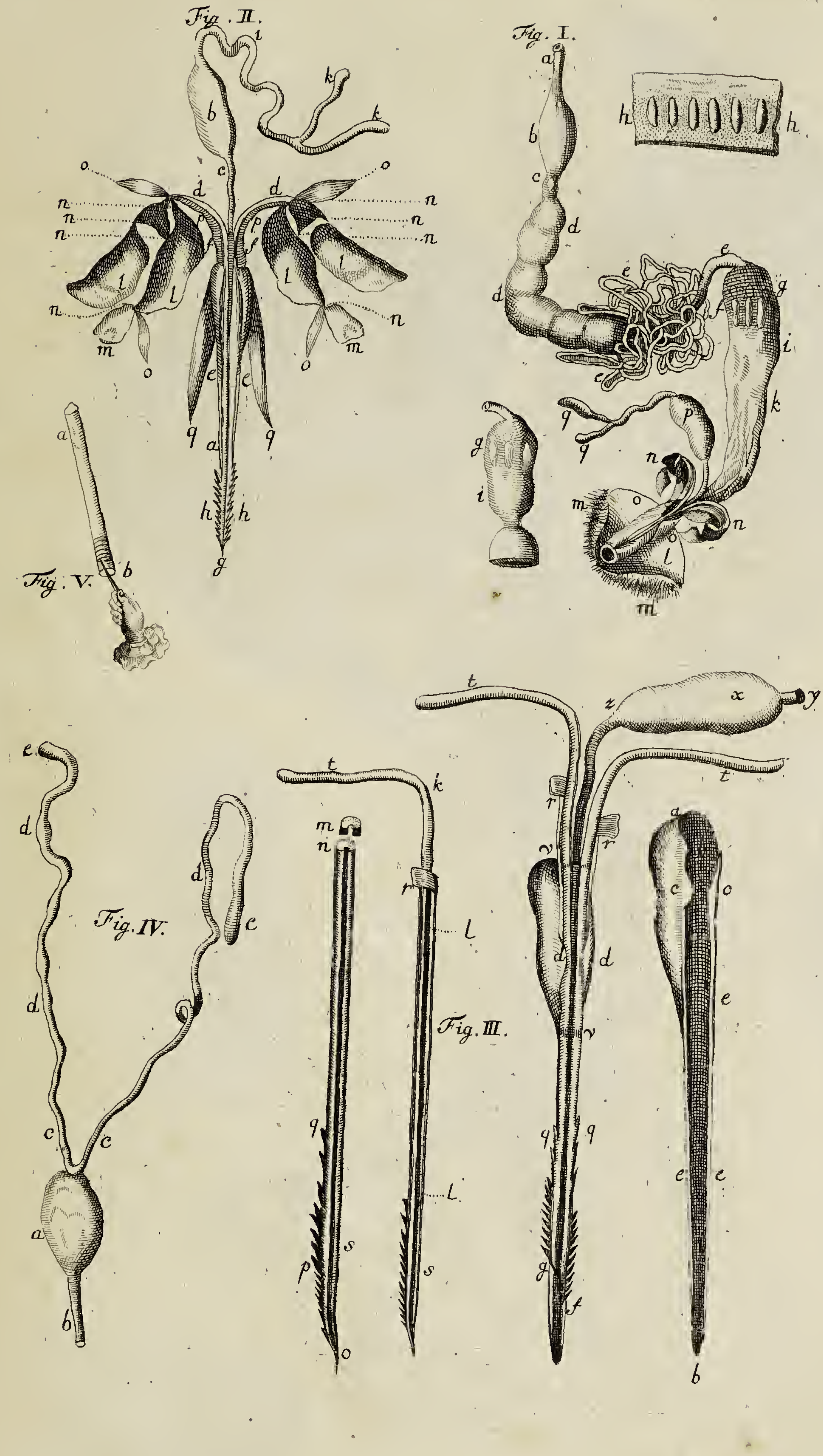

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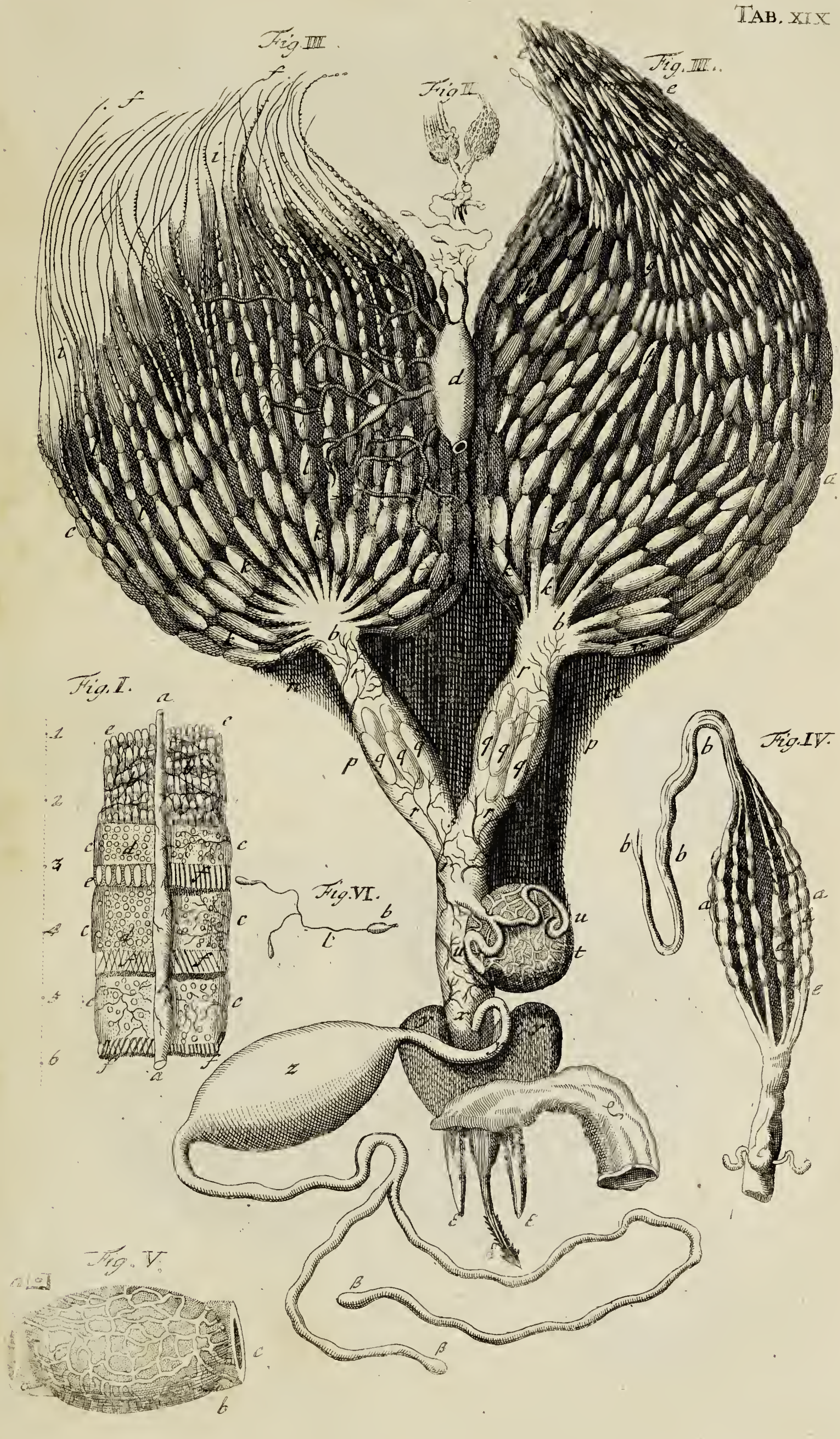

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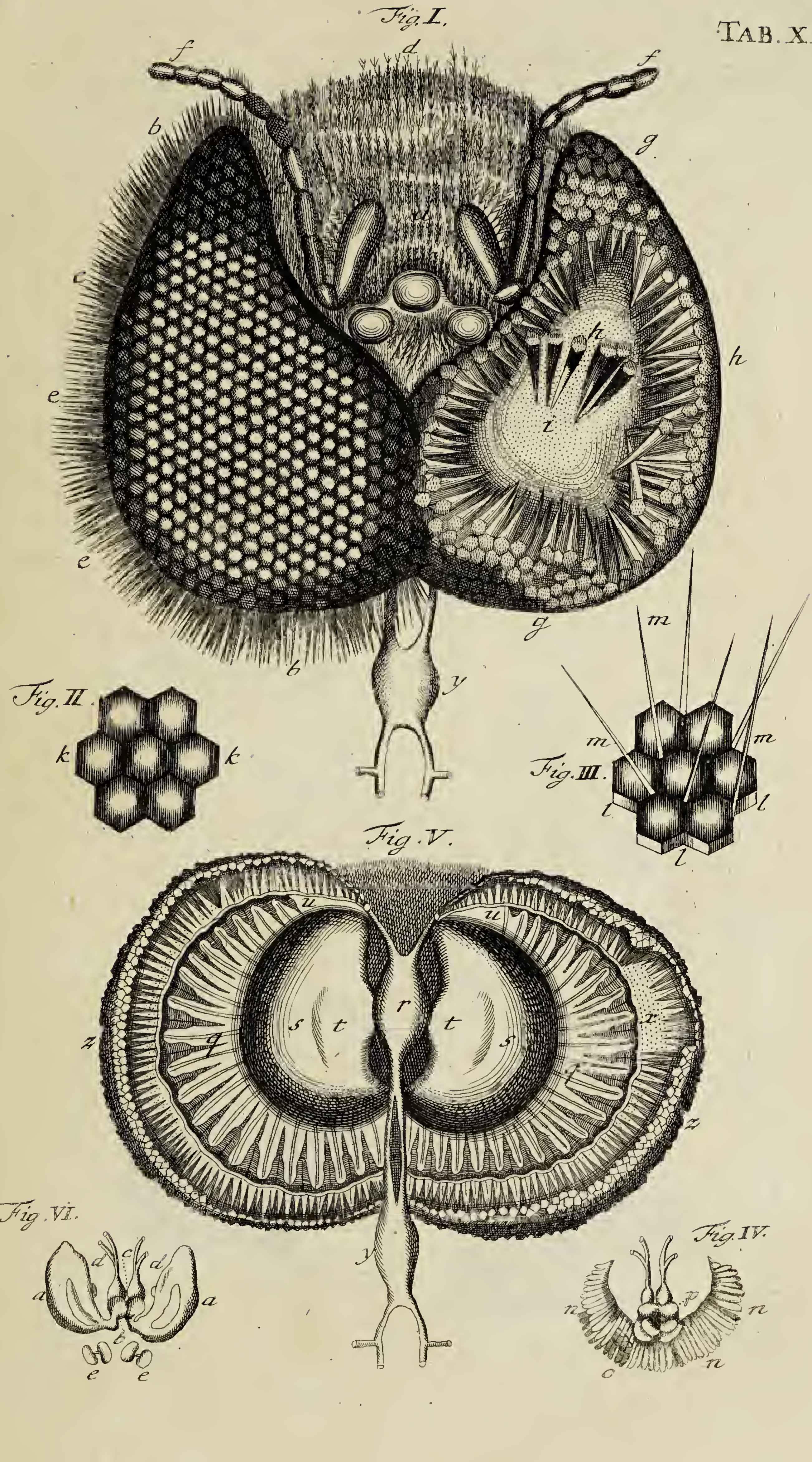

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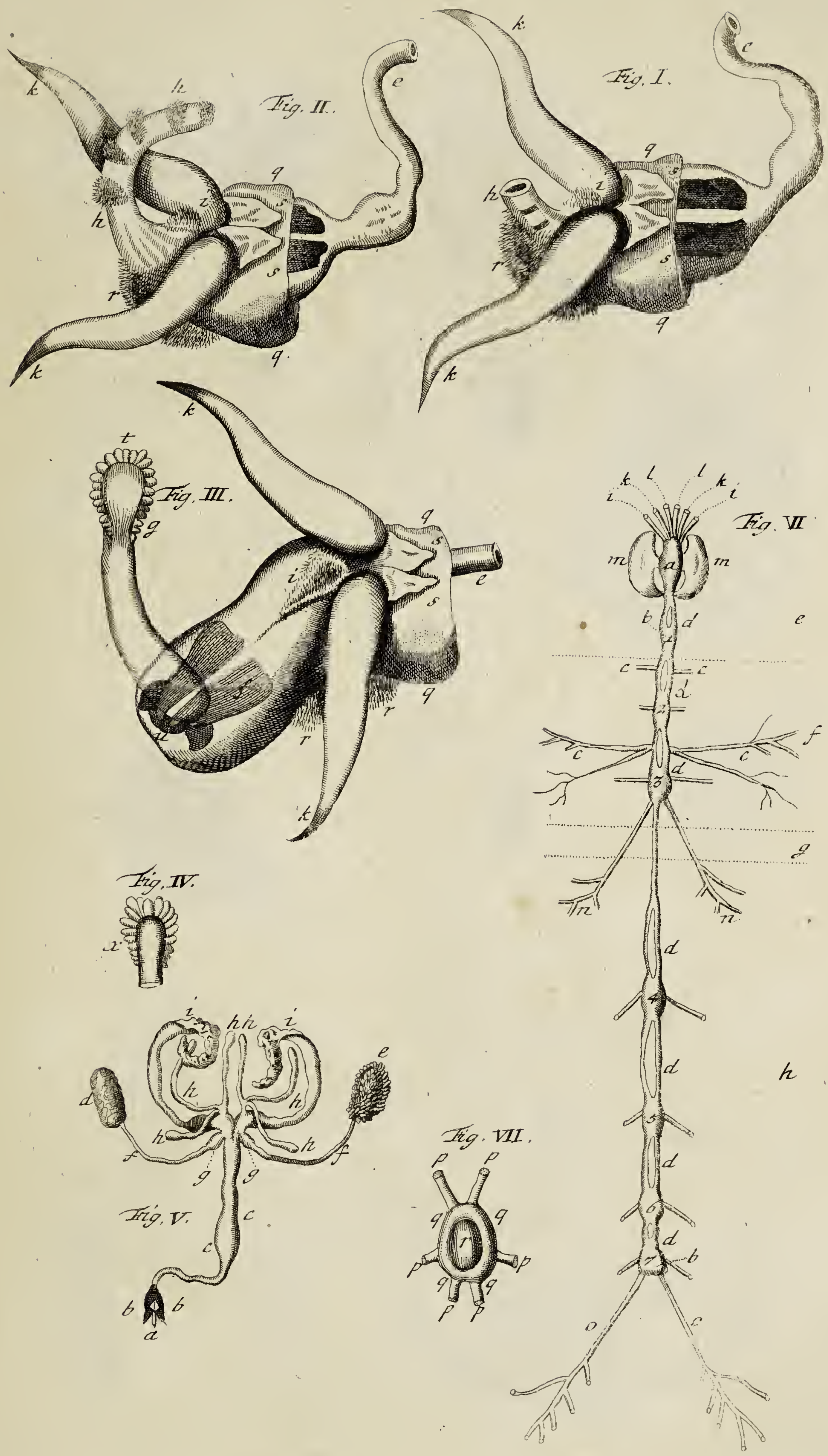

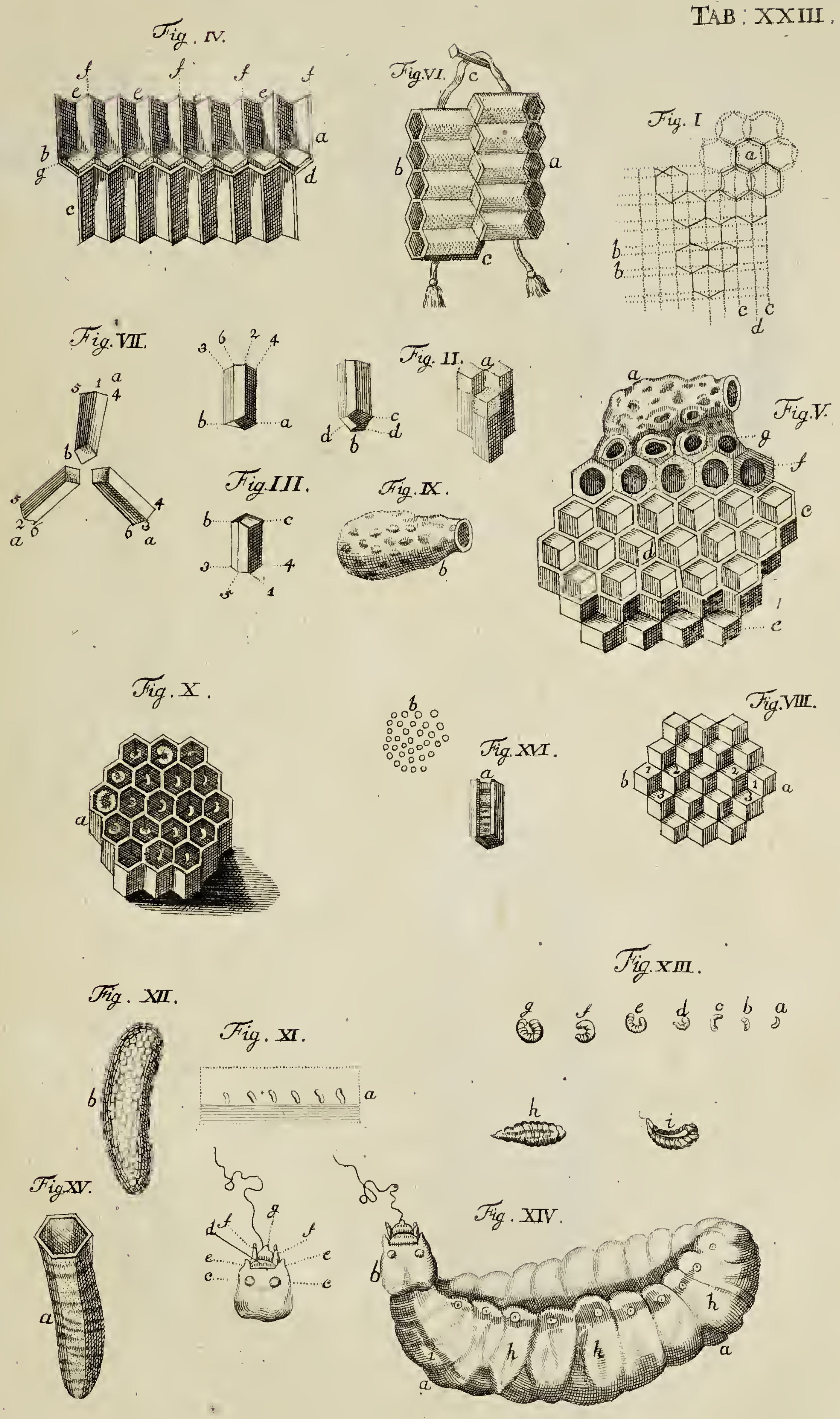
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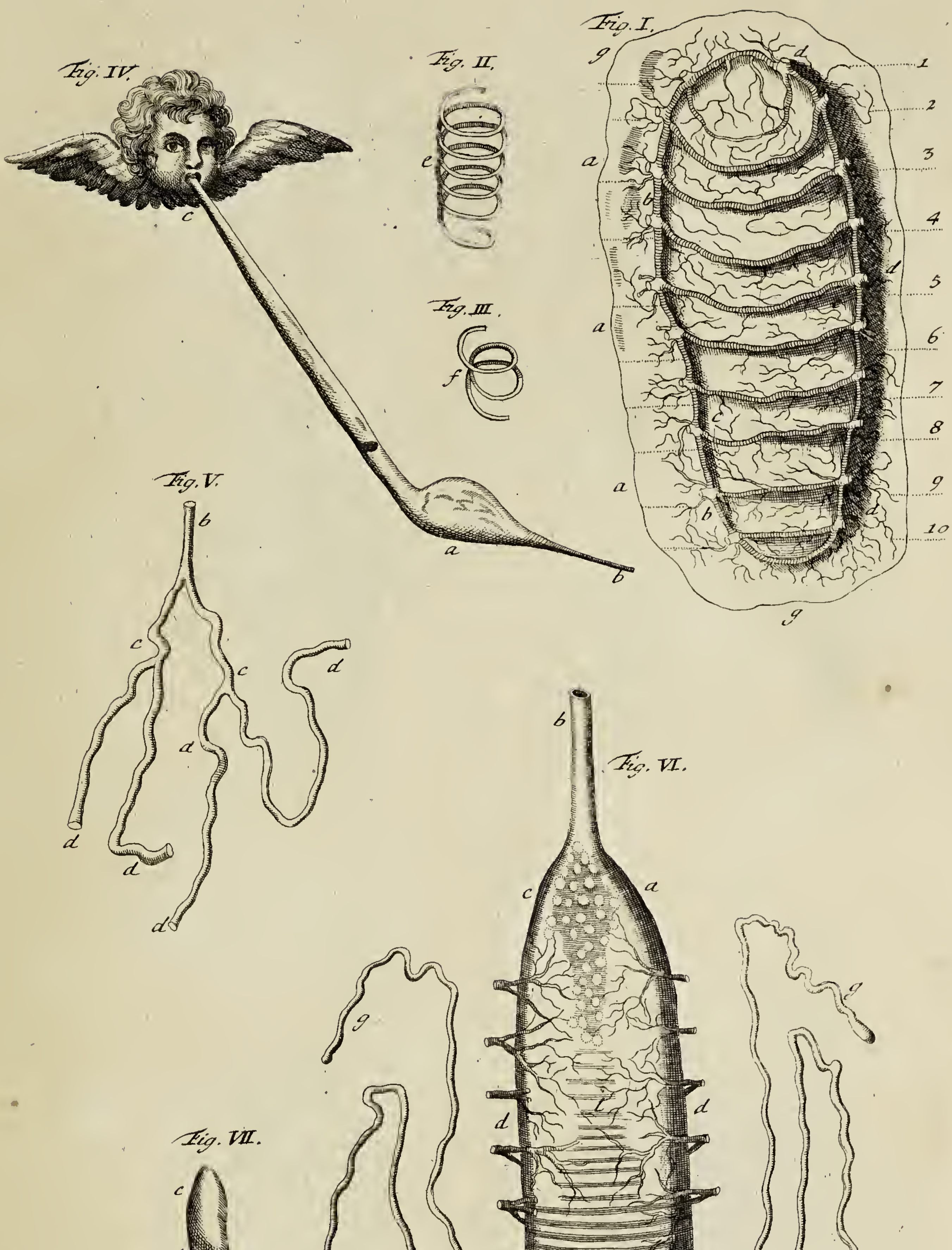

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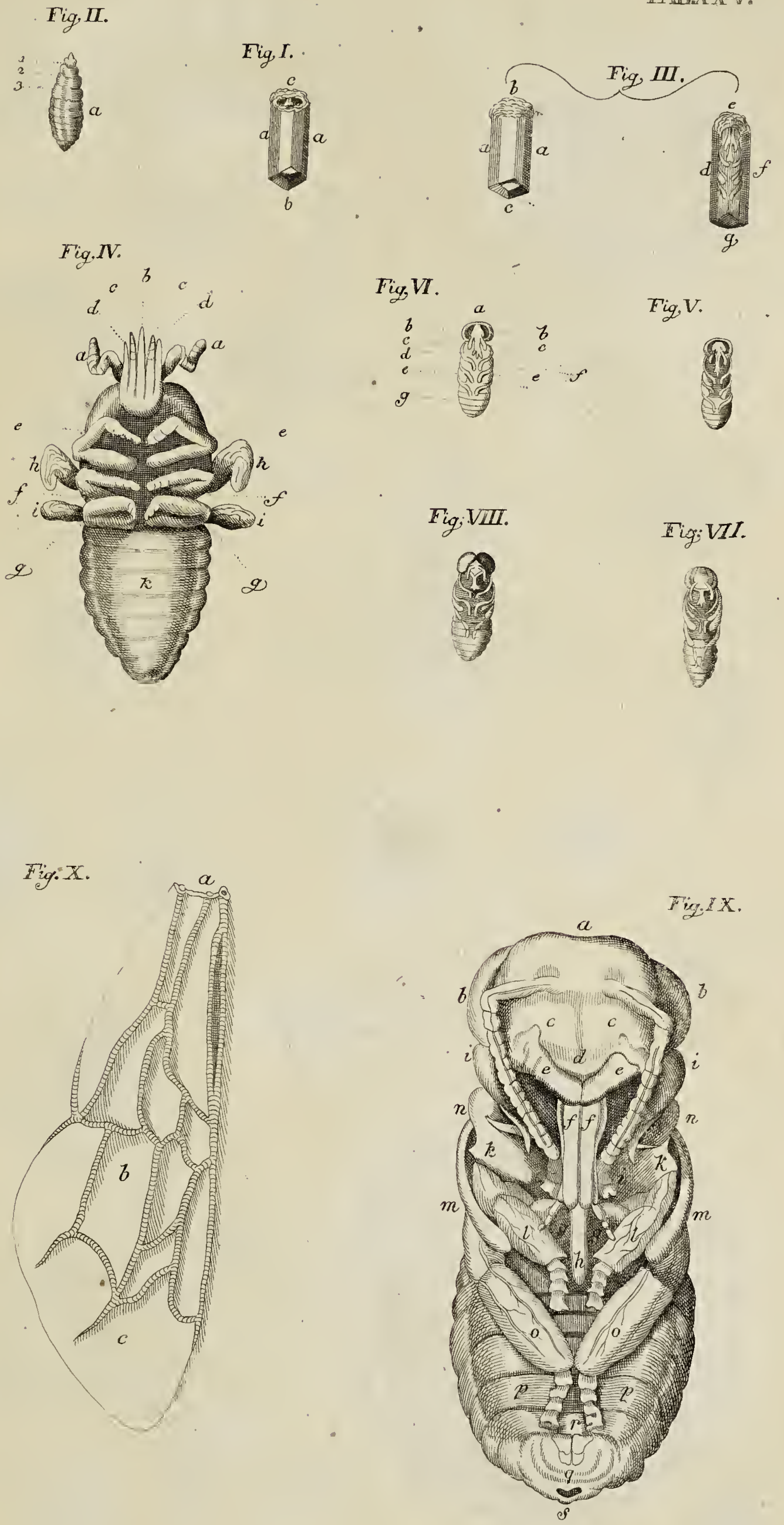
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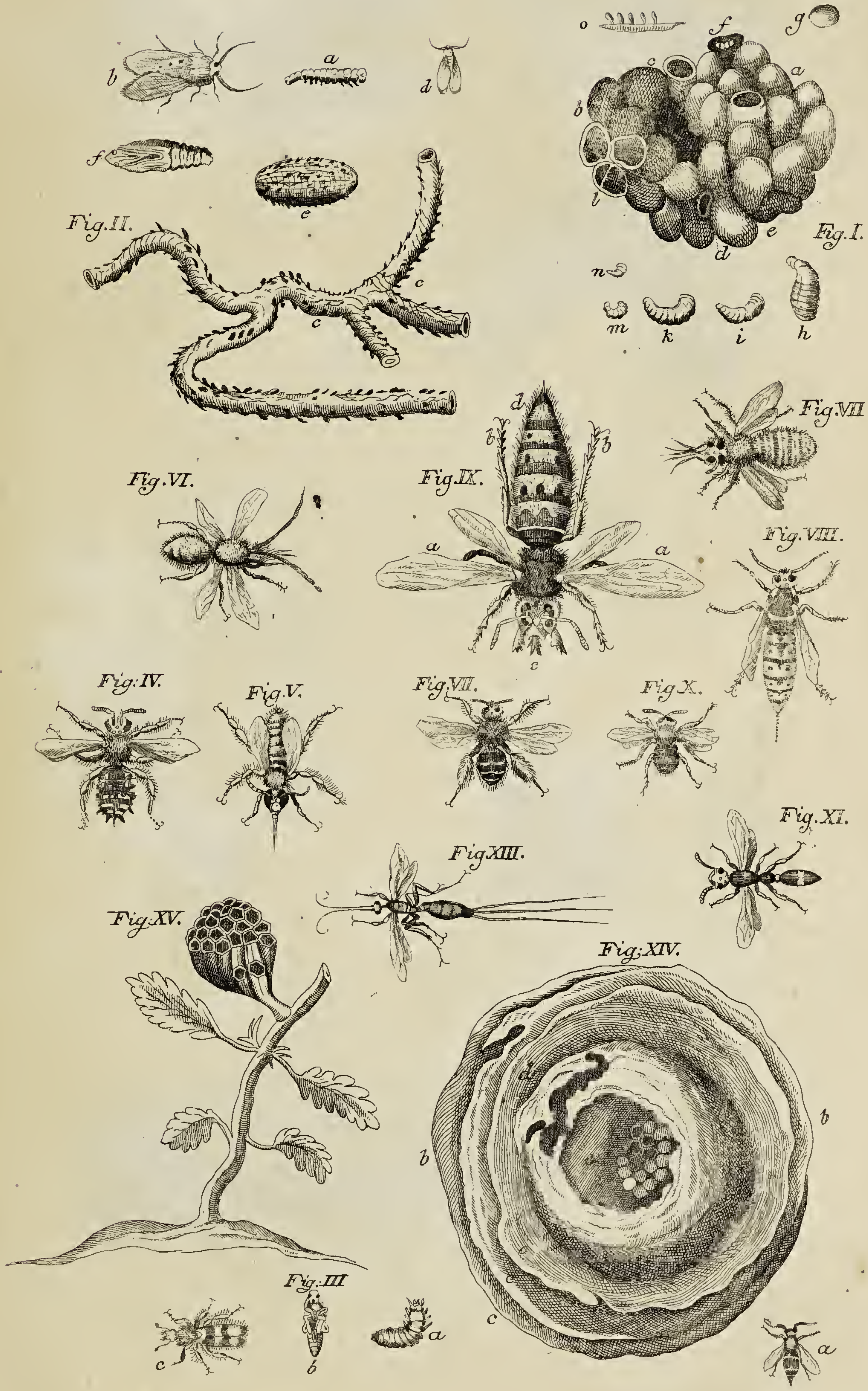
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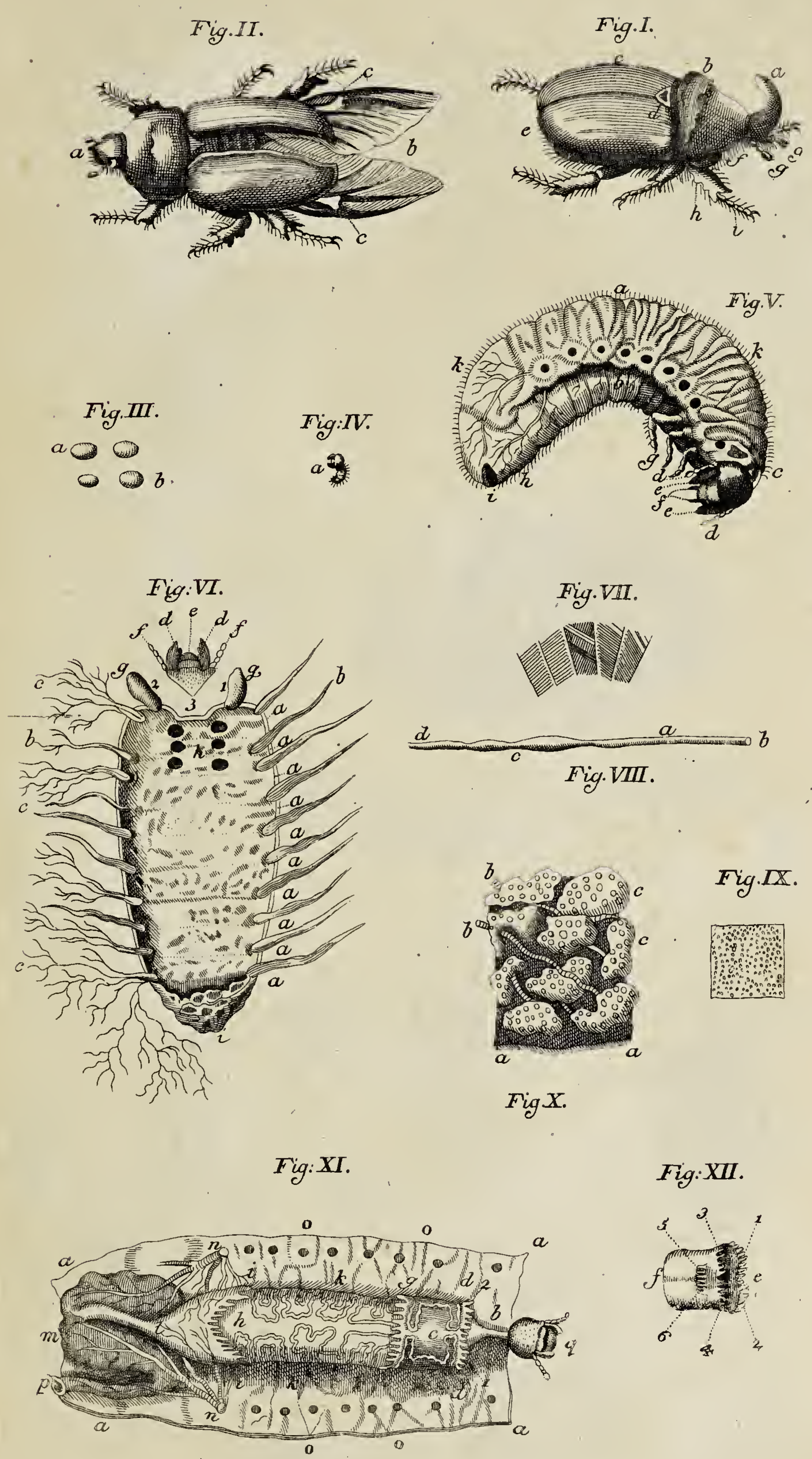
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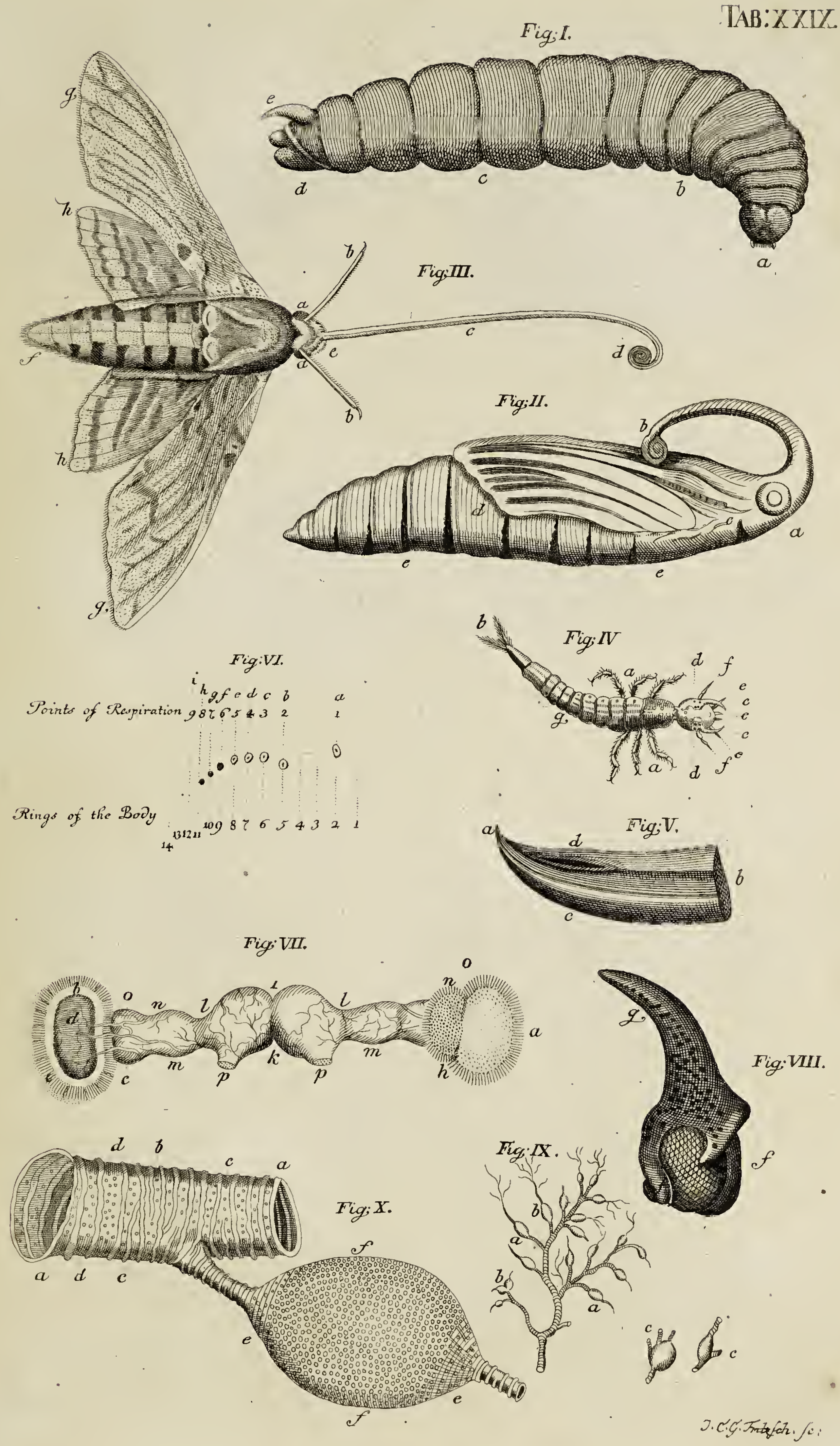

I. C. G. Fritzsch. sc.

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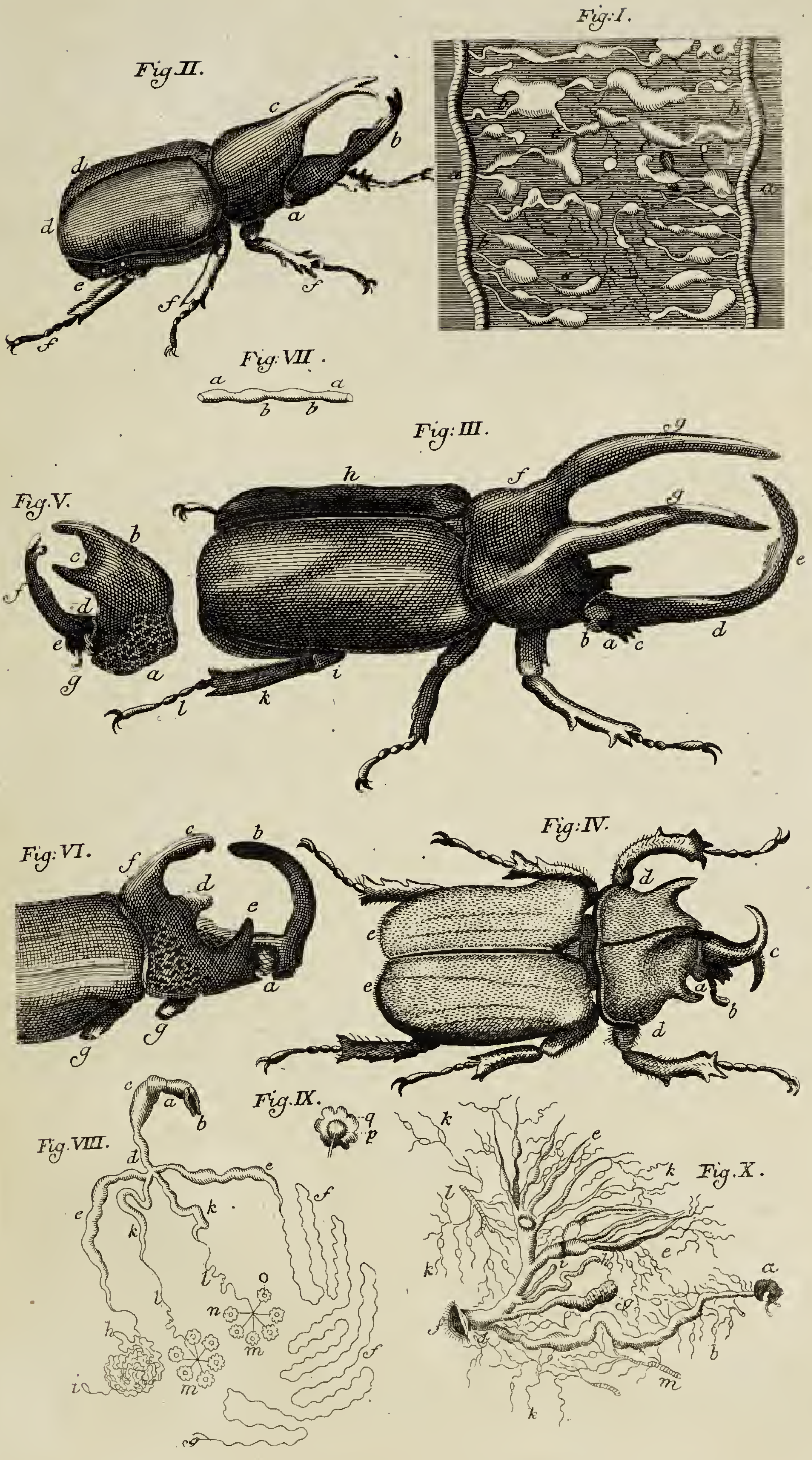
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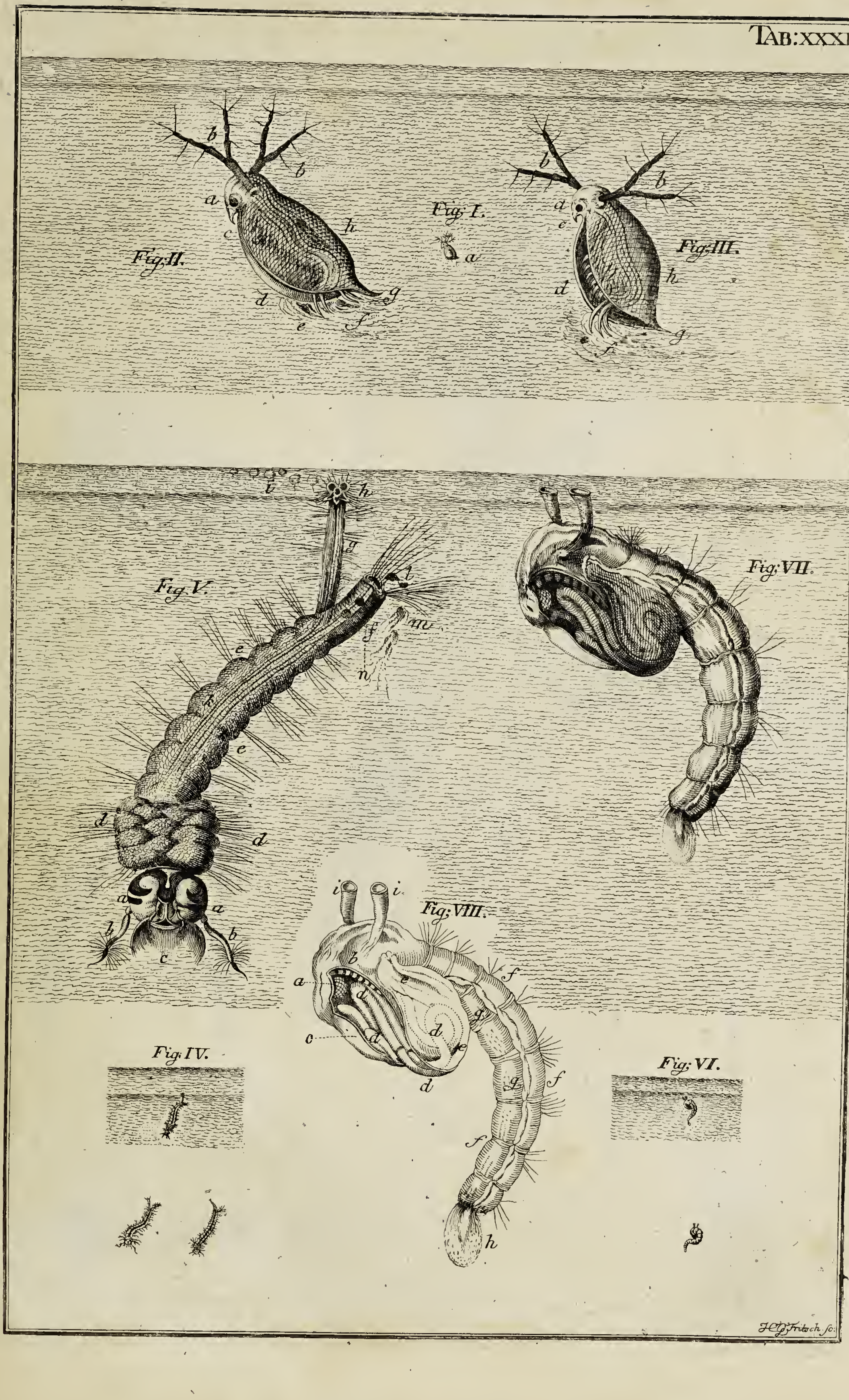
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H. G. Fritsch sc.


TAB.XXXII.
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J.C.G. Fritzsch f.

Order the Third
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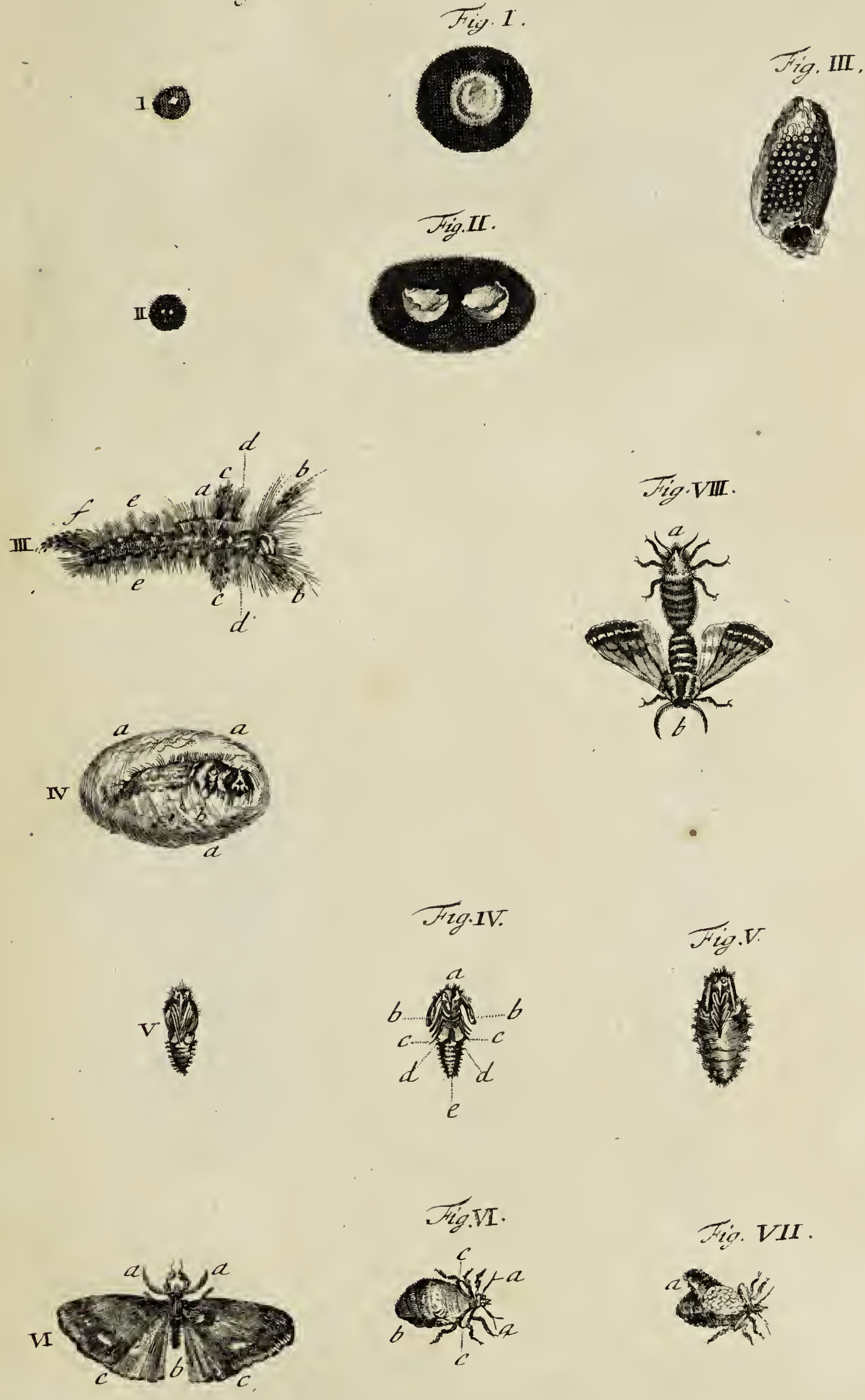

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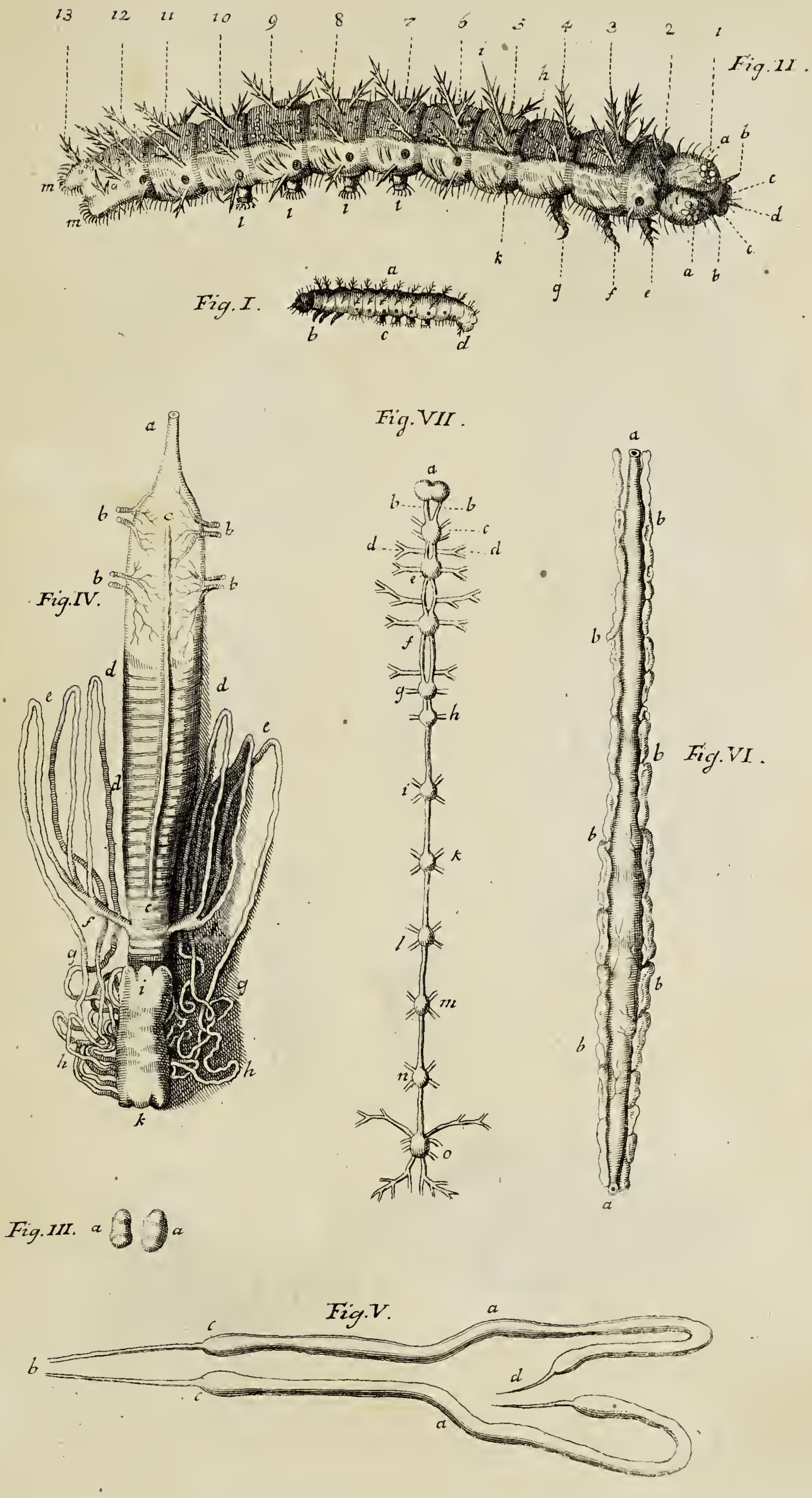

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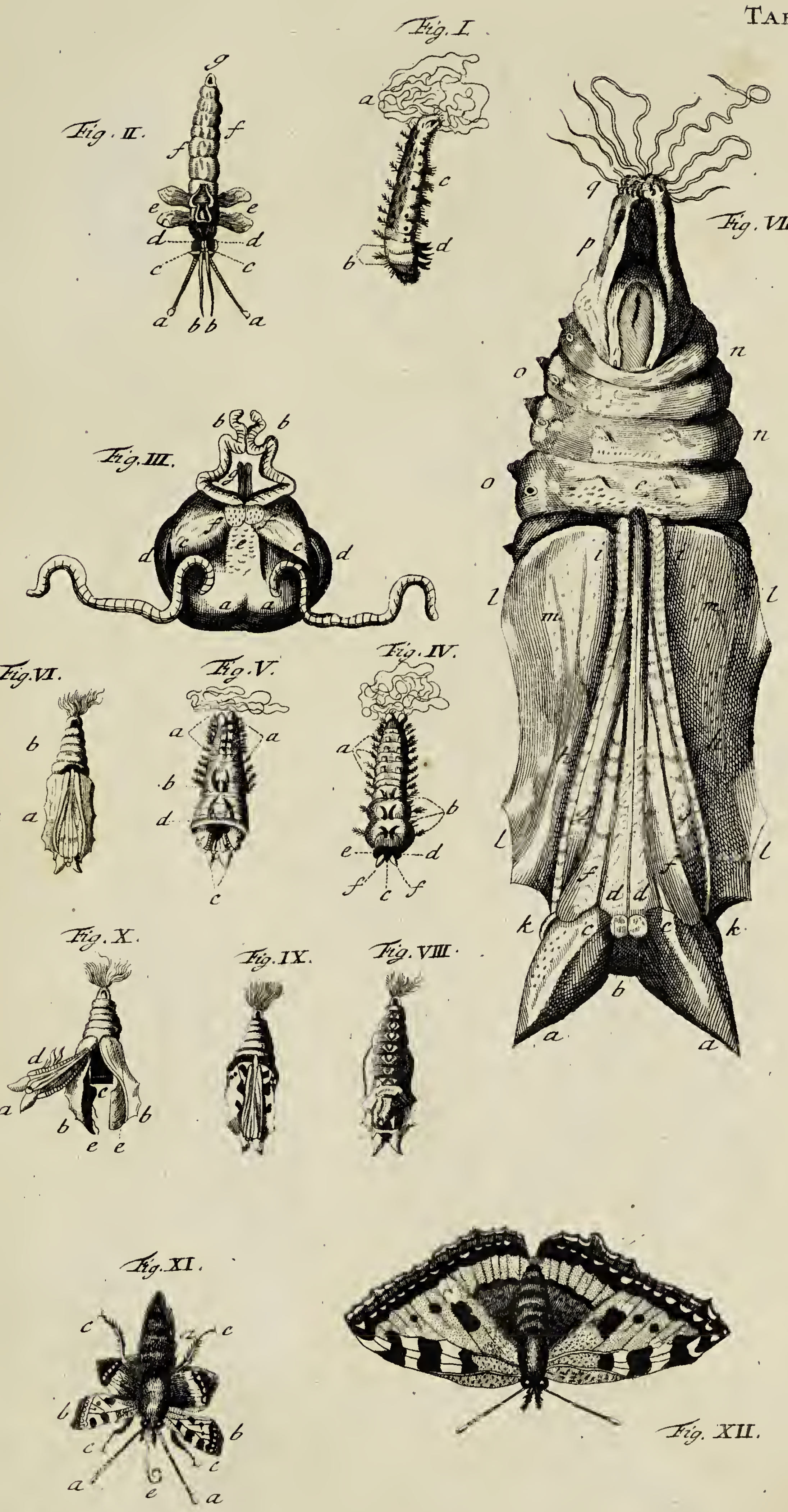
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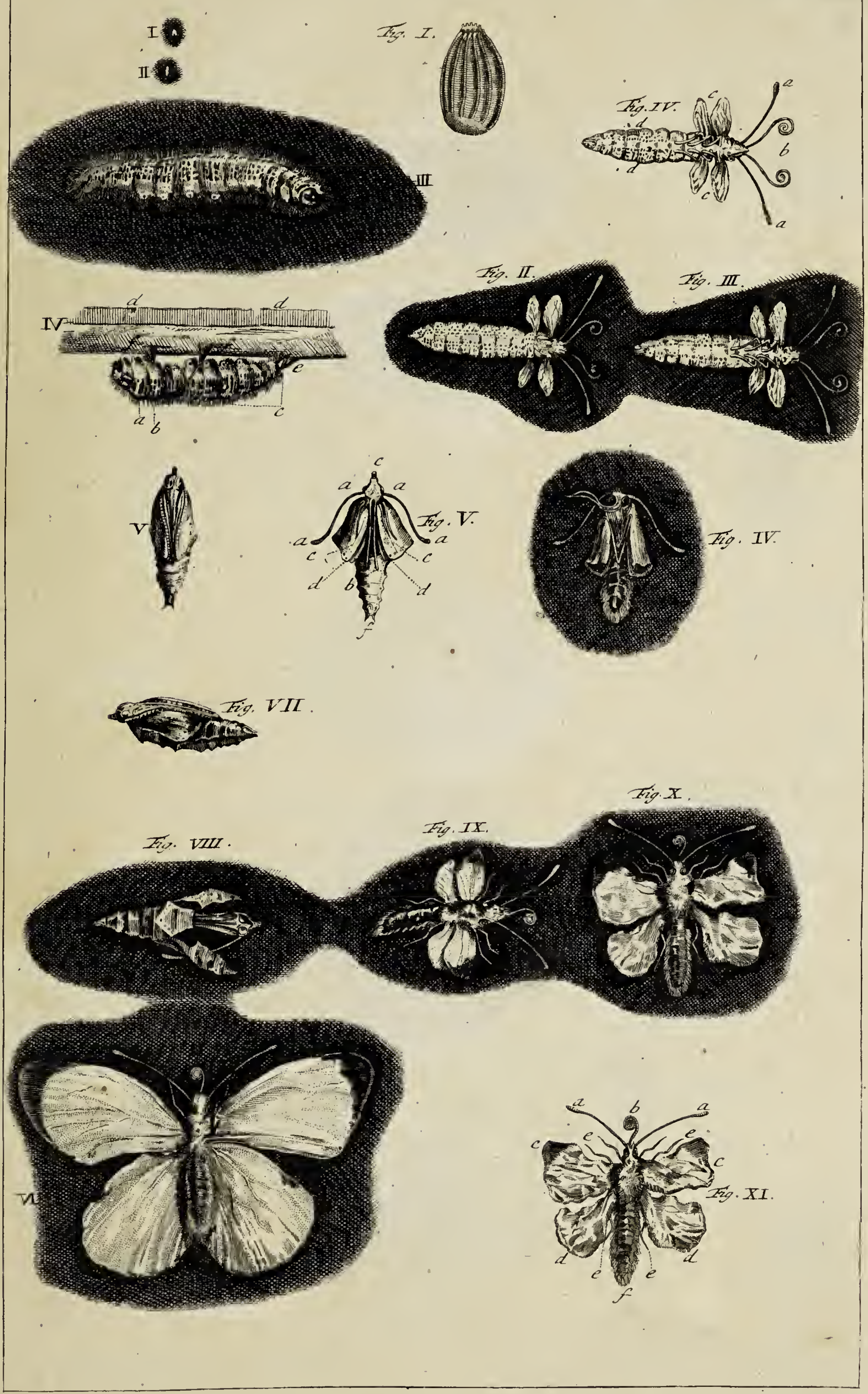
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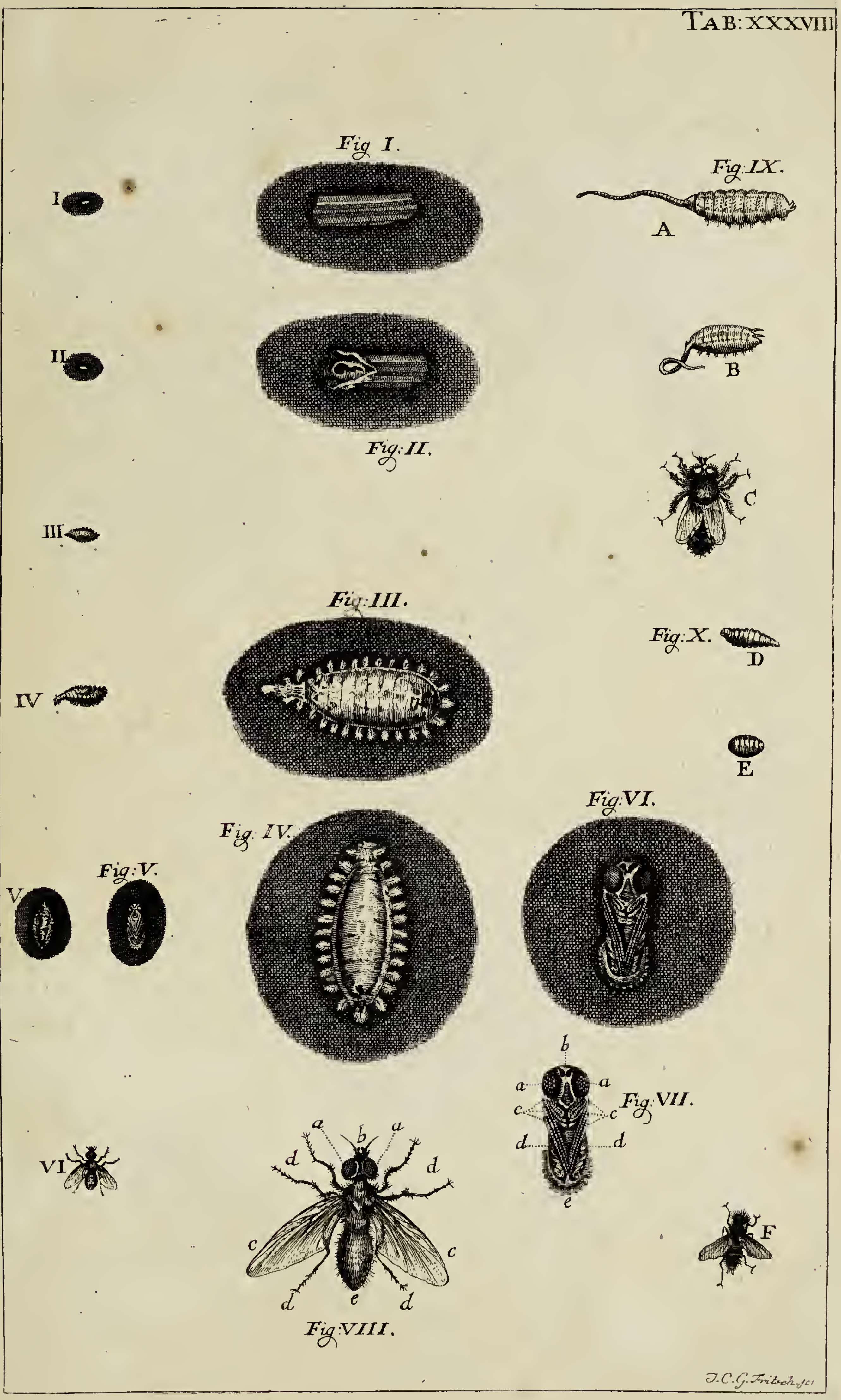
Fig. X.
Fig. XI.


TAB: XXXVIII
Fig I.
Fig: II.
Fig: III.
Fig: IV.
Fig: V.
Fig: VI.
Fig: VII.
Fig: VIII.
Fig: IX.
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I
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F
J.C.G. Fritsch sc.

TAB. XXXIX.

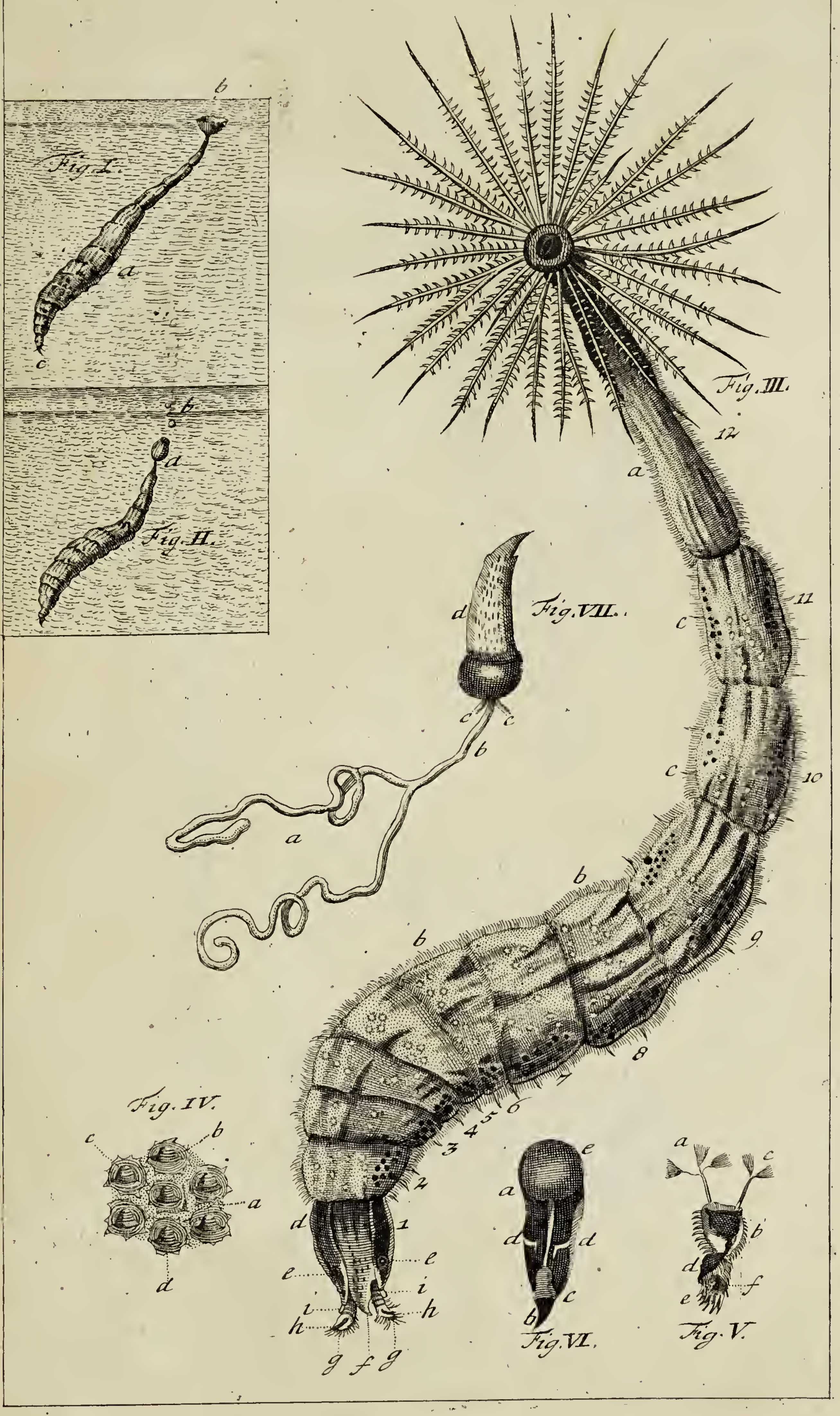


Fig. III.

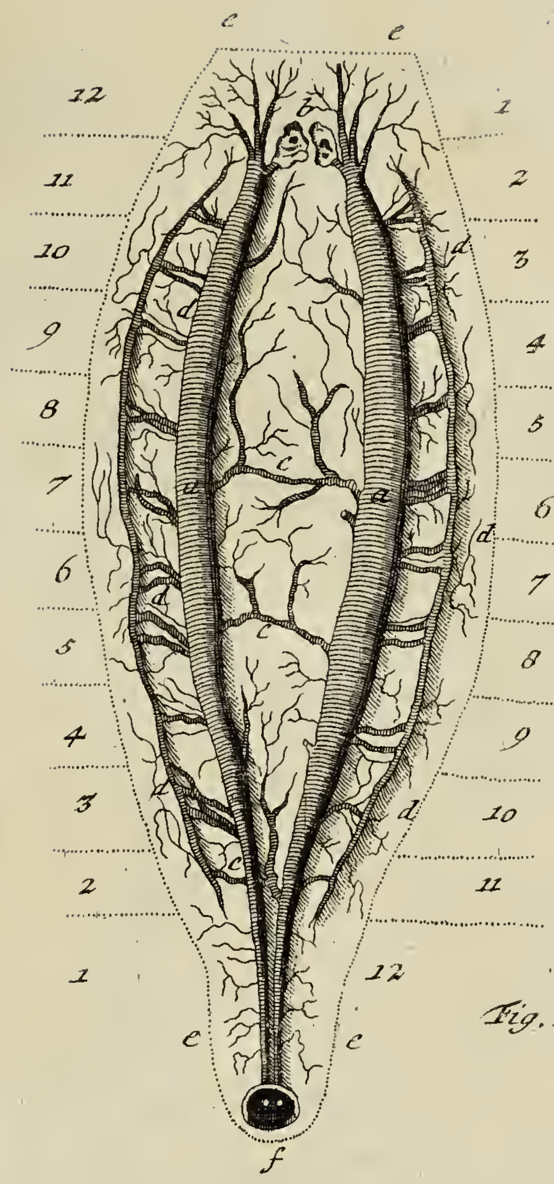
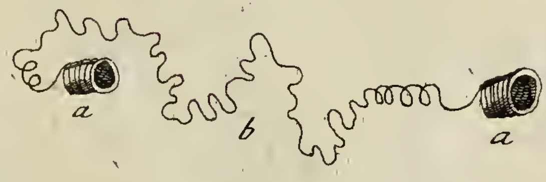


Fig. I.

Fig. IV.

Fig. II.



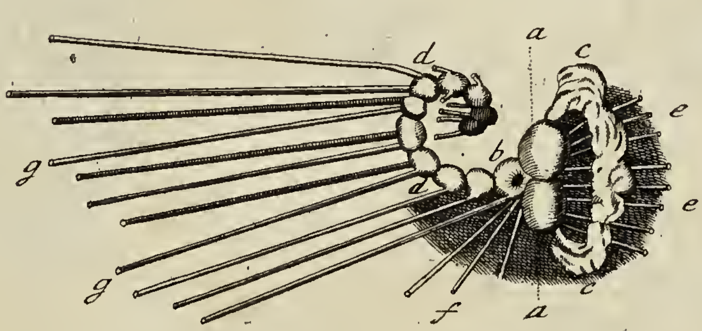
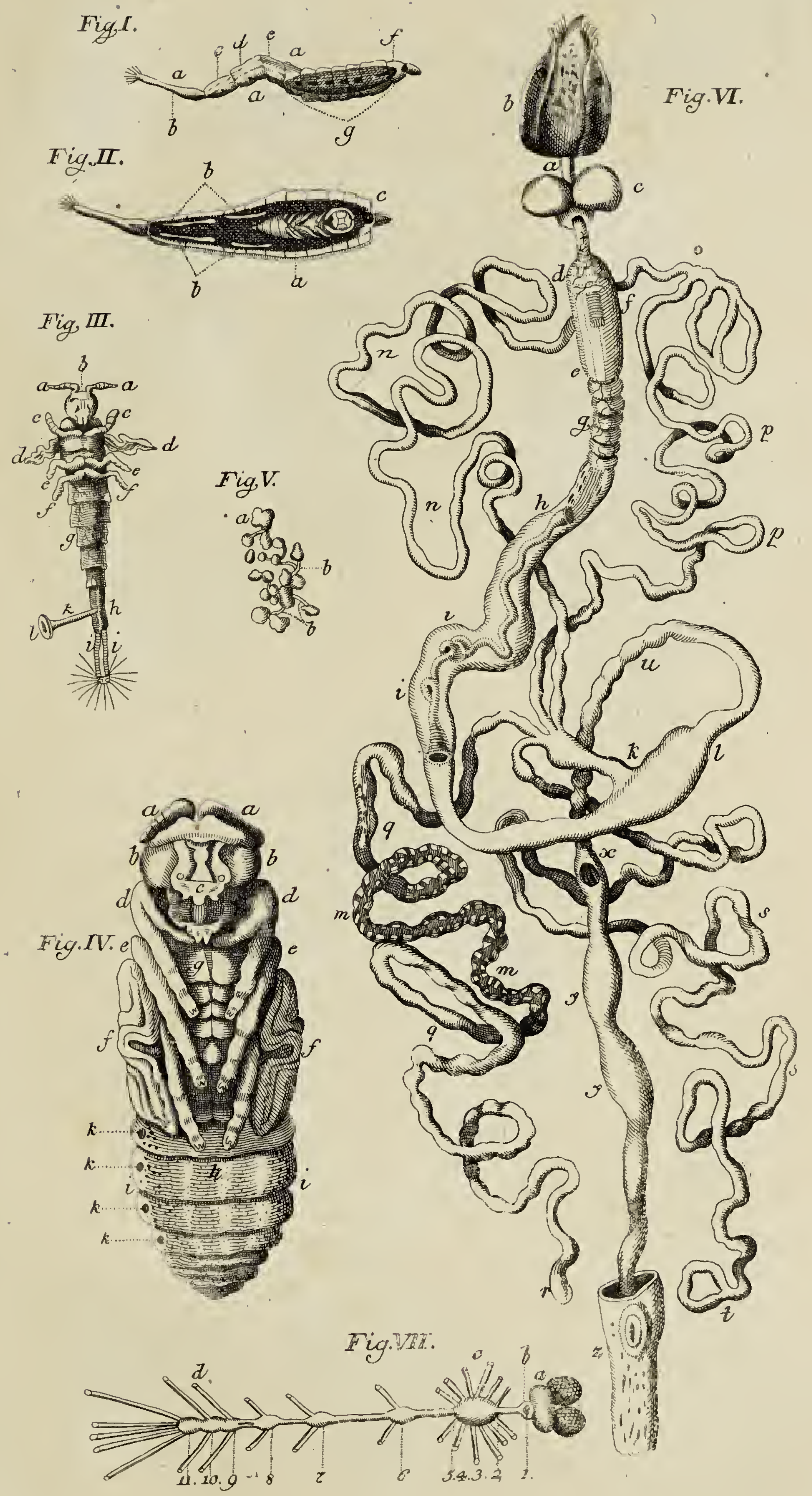
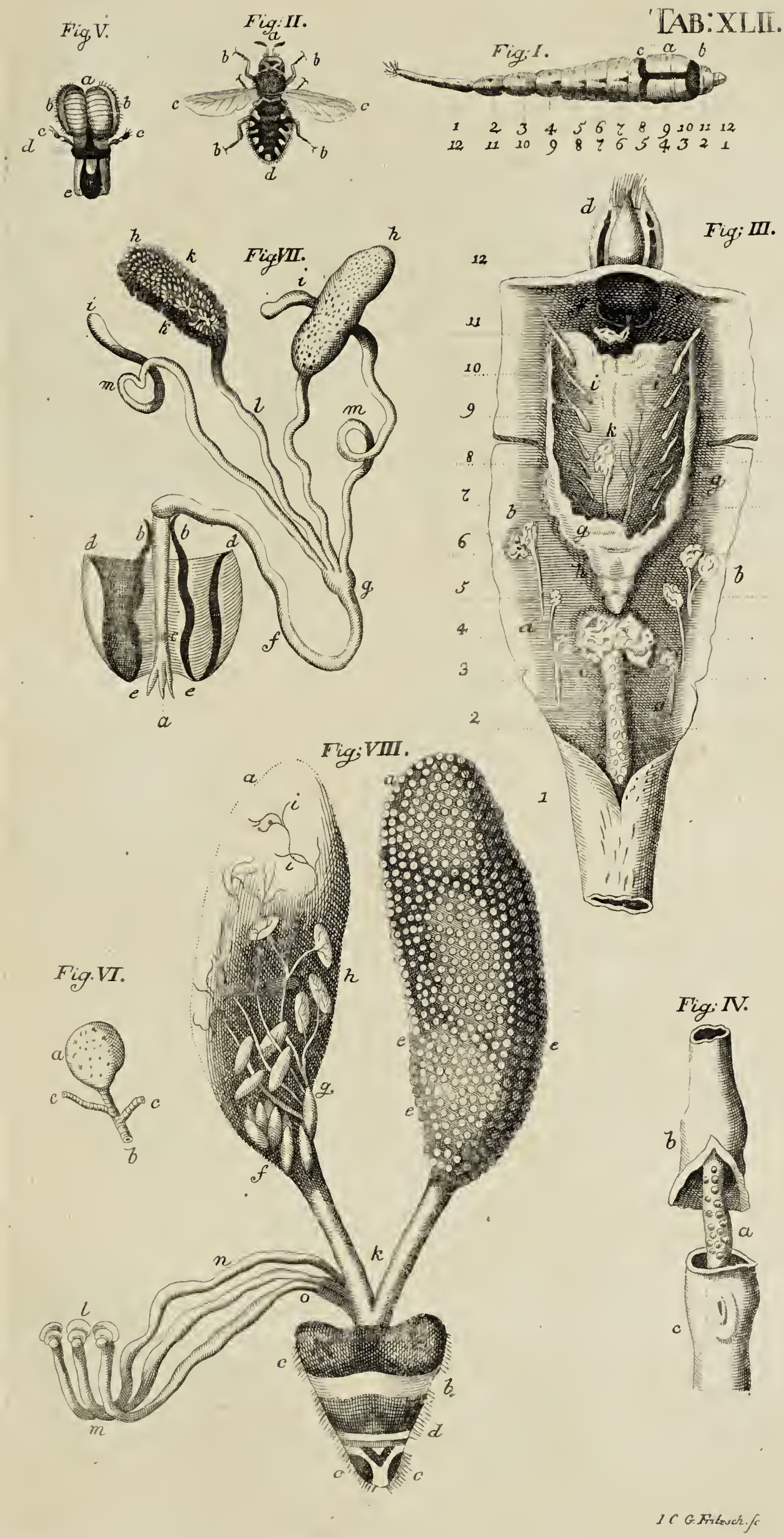


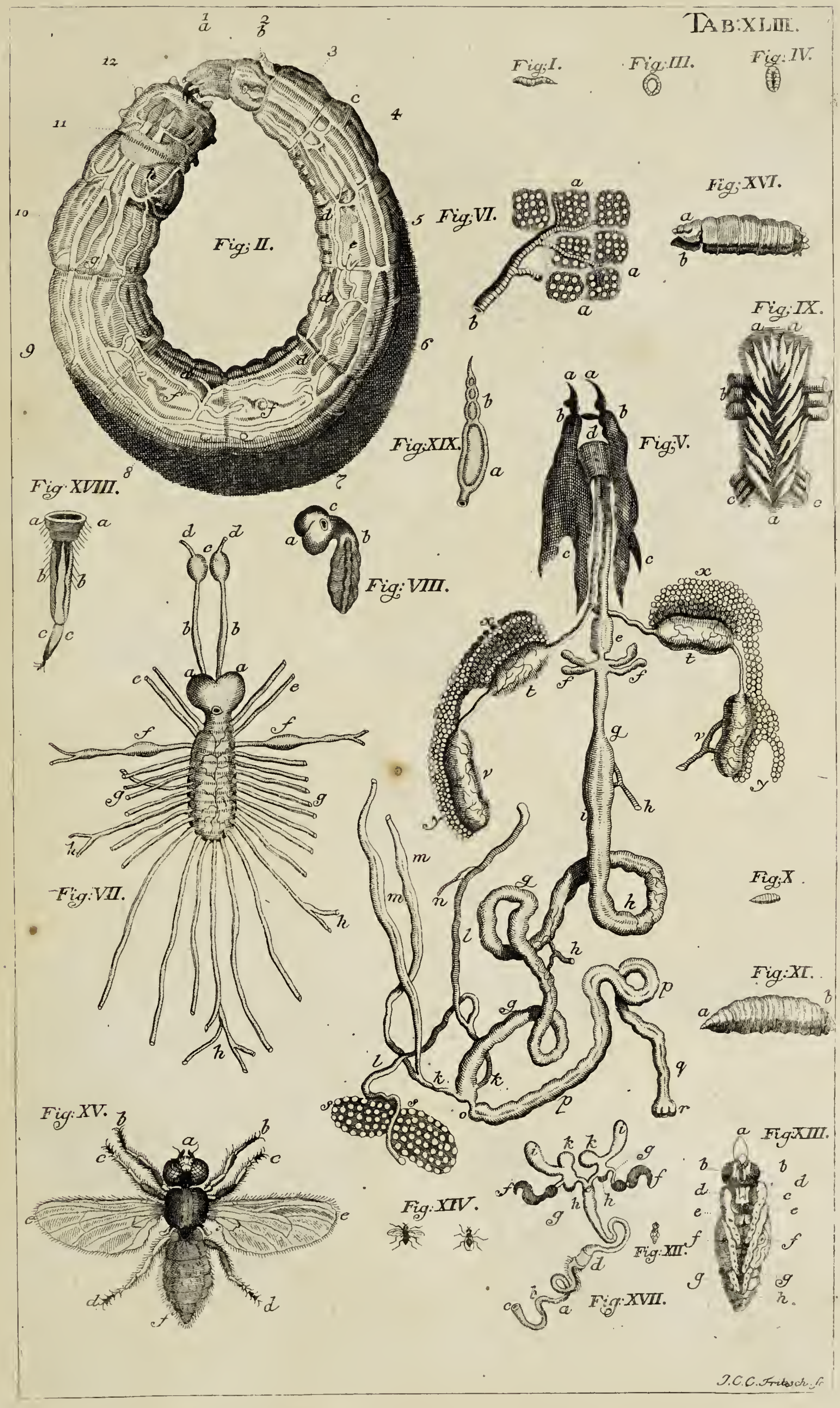
Fig. V.

Tab: XLI





I C G Fritzsch sc


TAB:XLIII.
Fig;I.
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Fig;IV.
Fig;II.
Fig;VI.
Fig;XVI.
Fig;IX.
Fig;XIX.
Fig;V.
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Fig;XI.
Fig:XV.
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Fig:XII.
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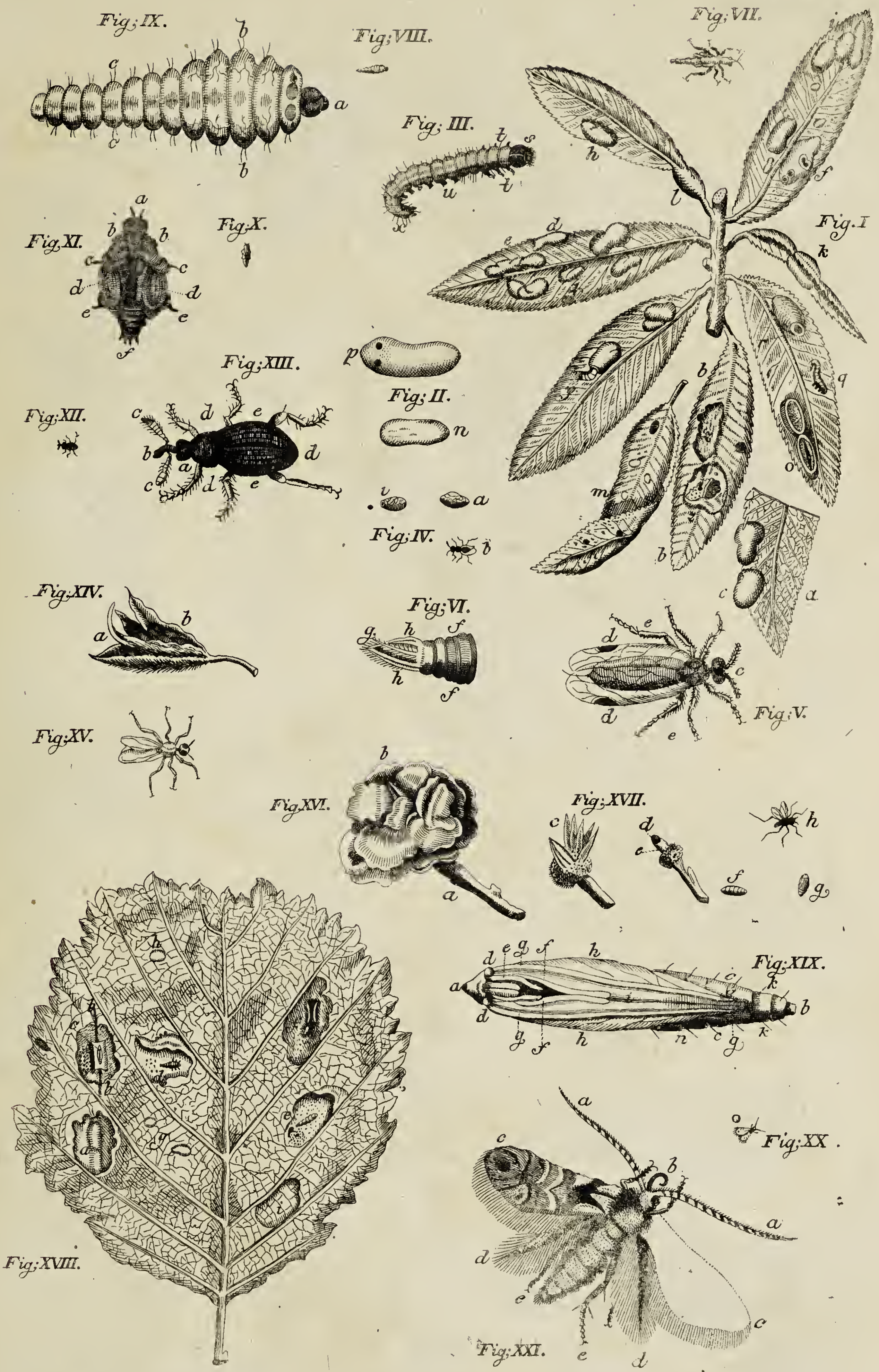
Fig:XVII.
J.C.C.Fritsch.sc.

TAB: XLIV.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TAB: XLV.

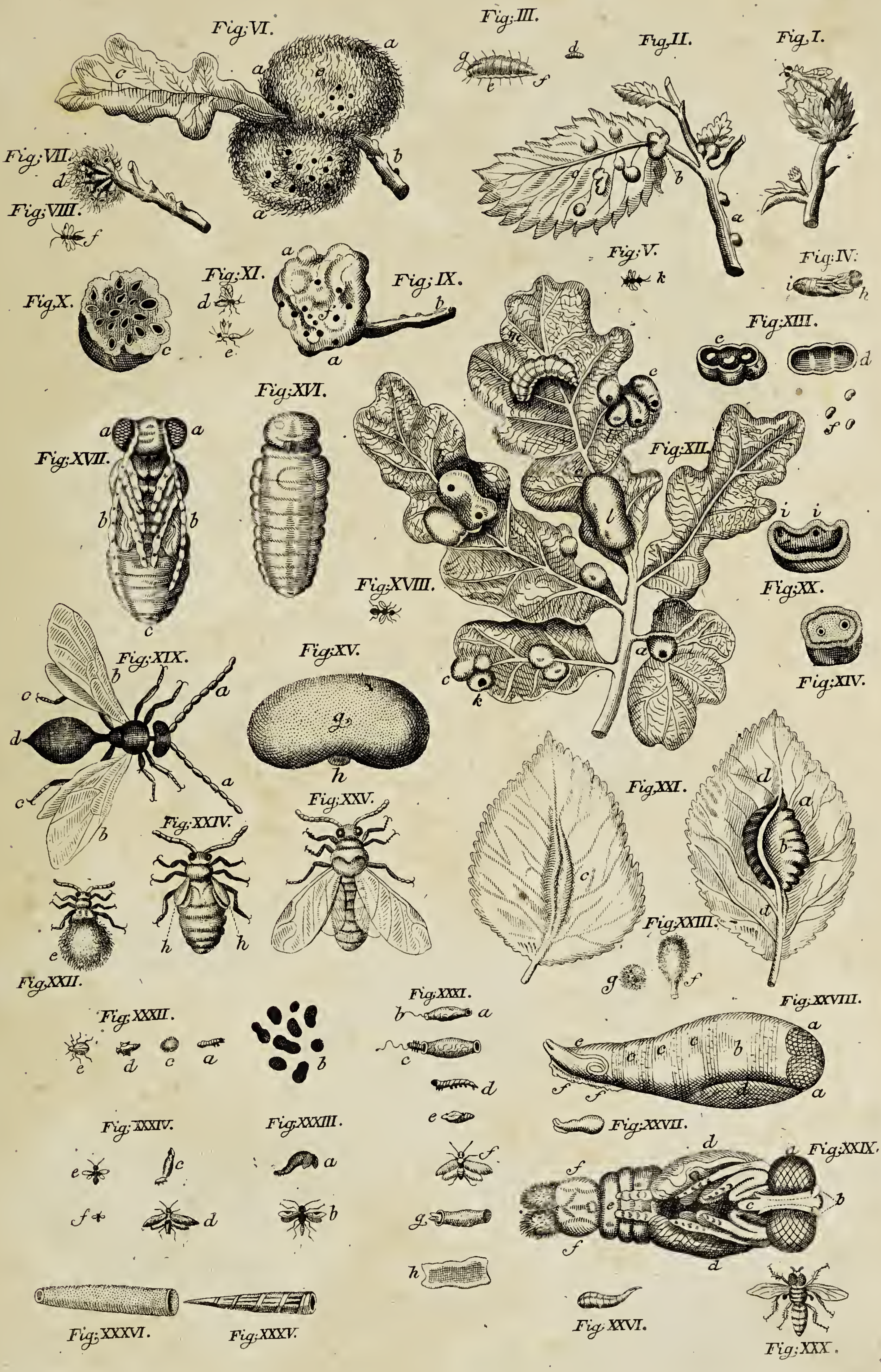

Fig: VI.
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Fig: XXXIV.
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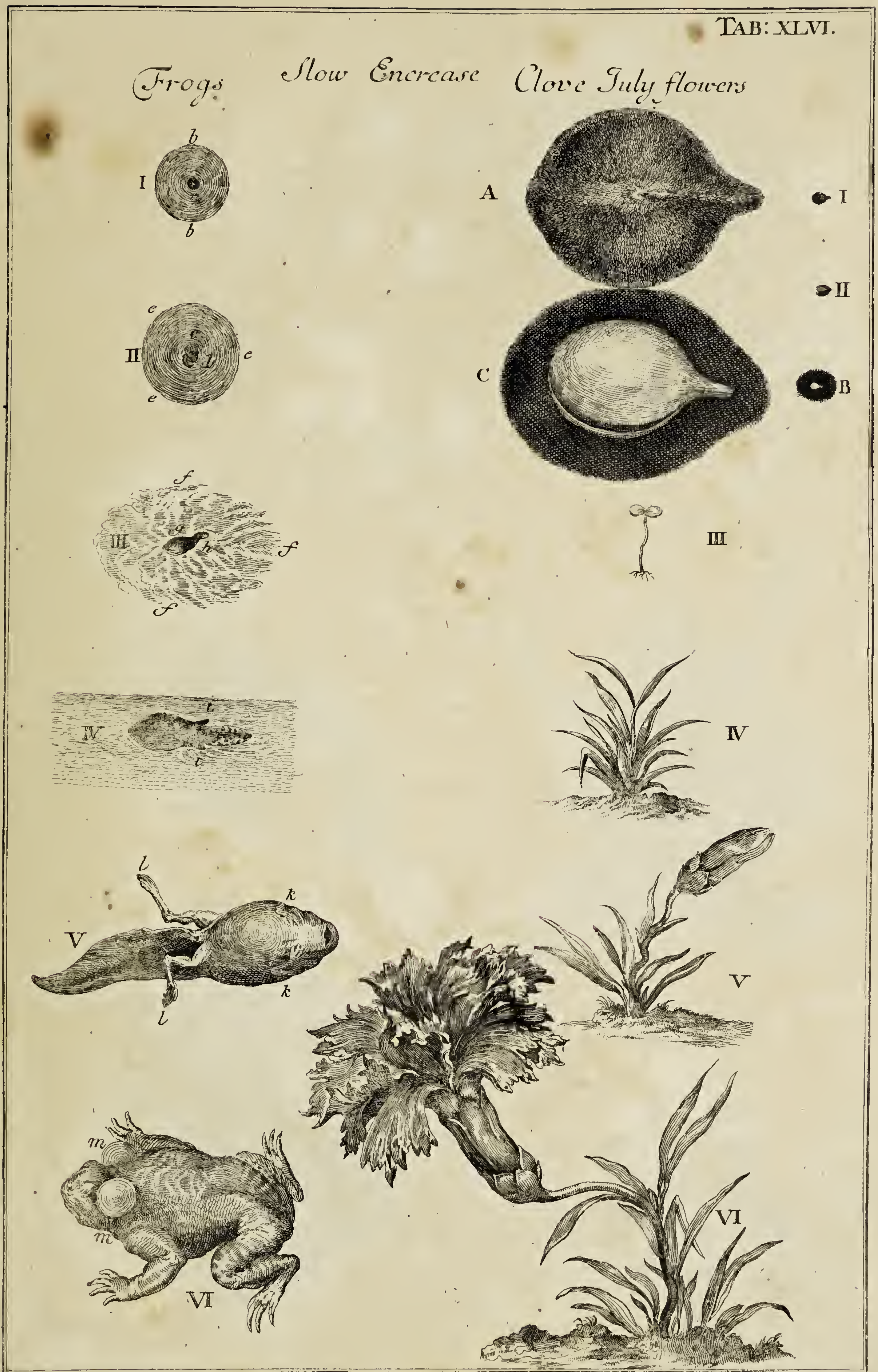
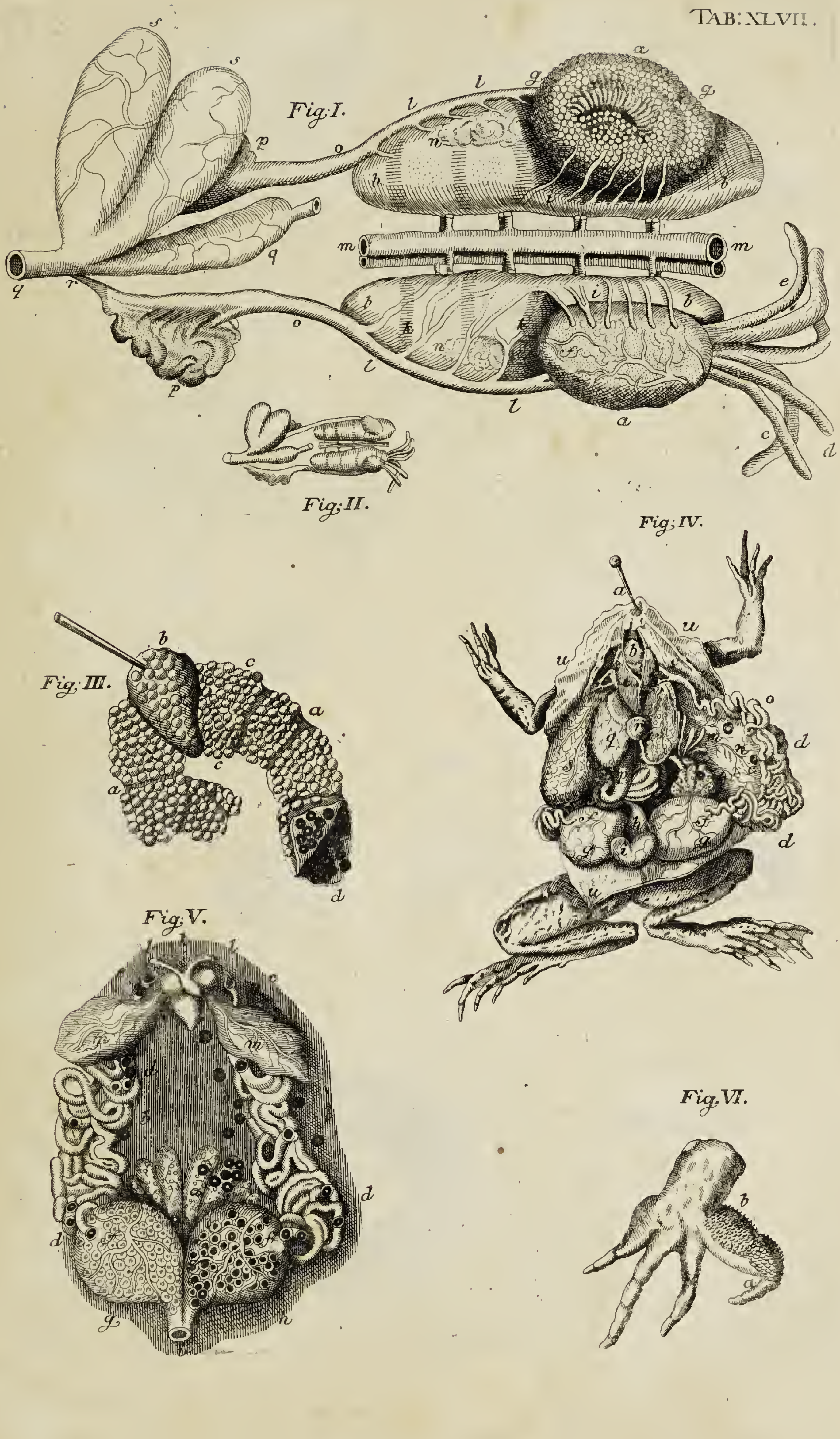


A.G. Fritzsch sc:

TAB: XLVII.



TAB XLVIII.

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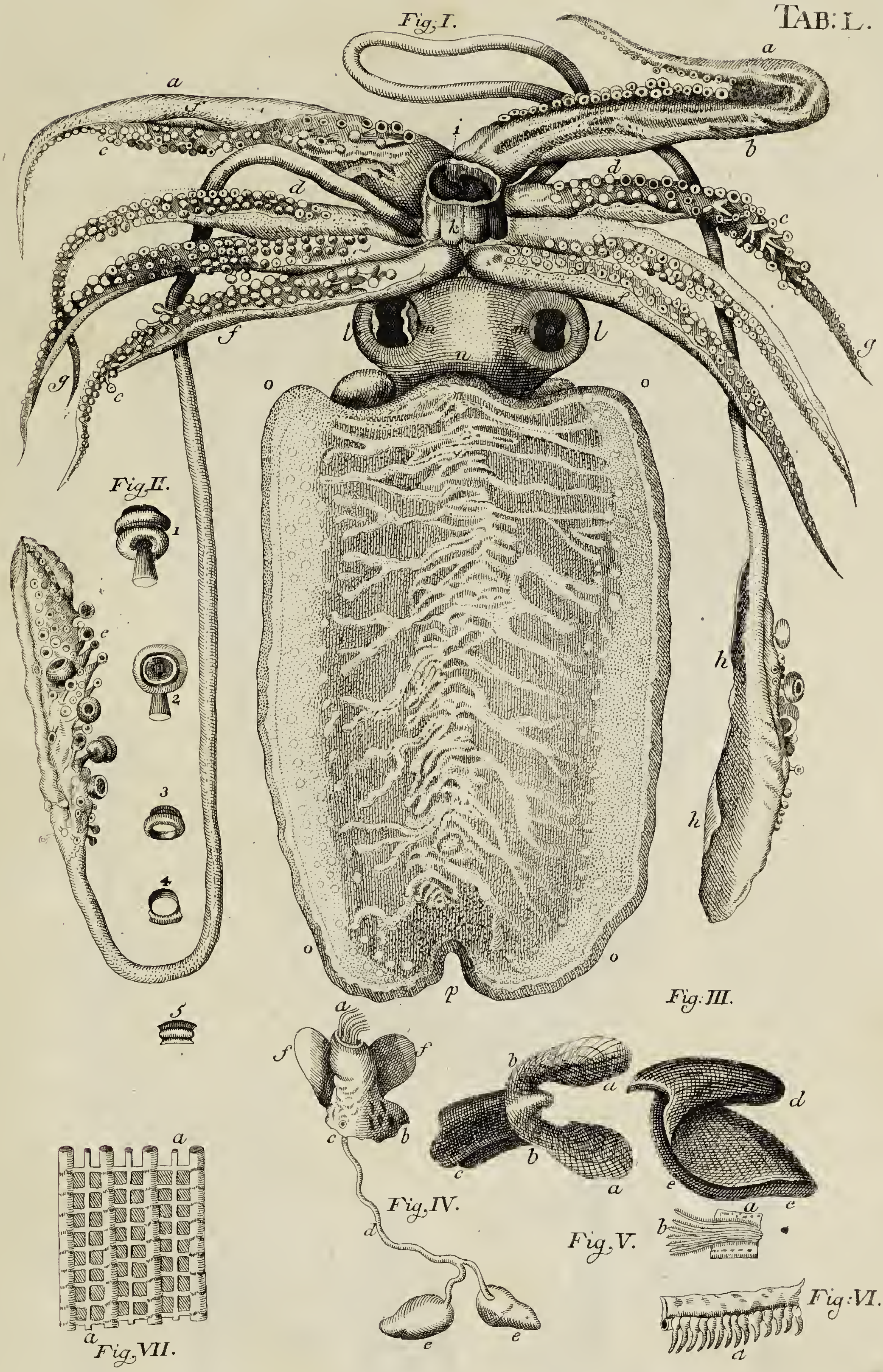
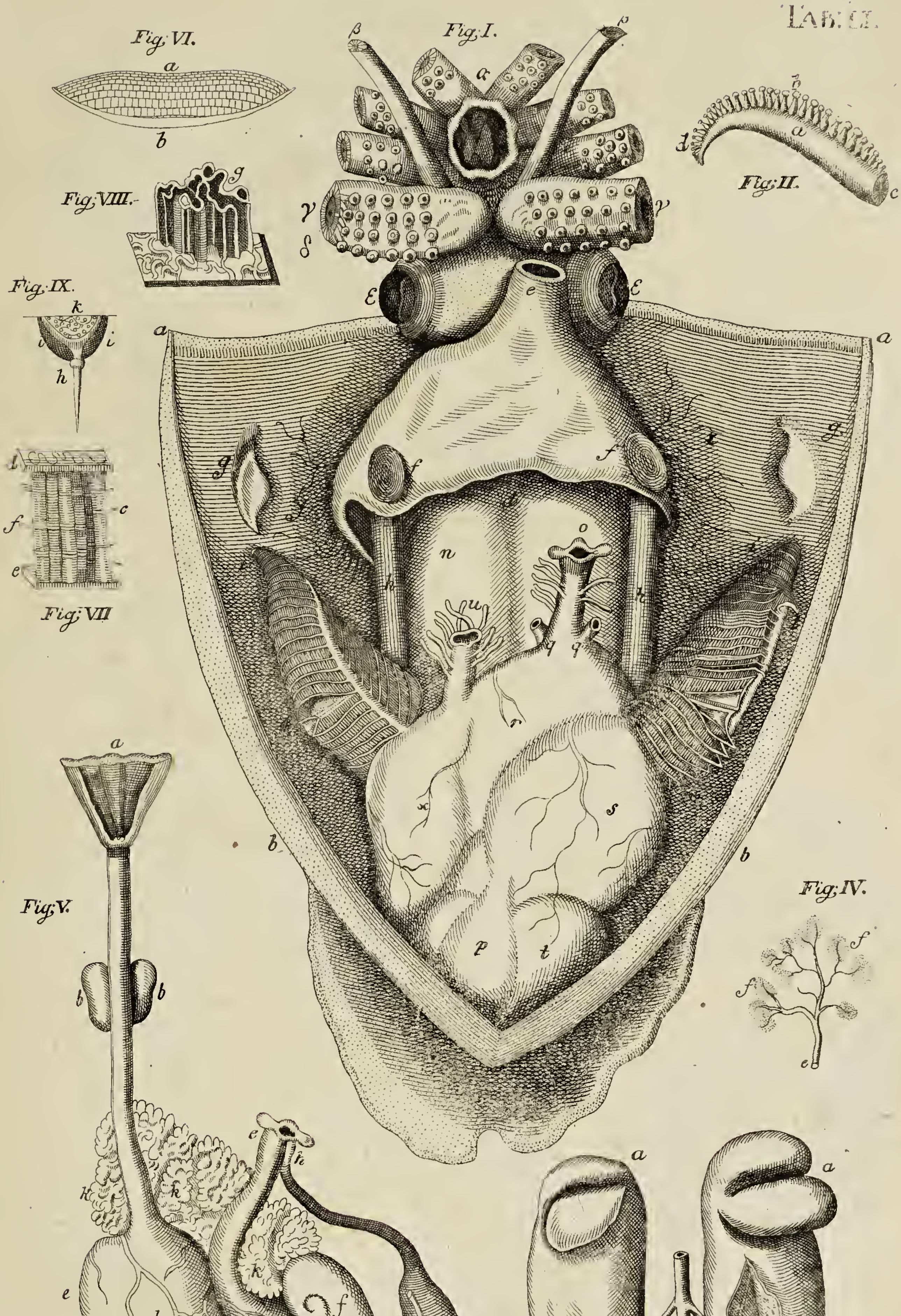
TAB: XLIX.

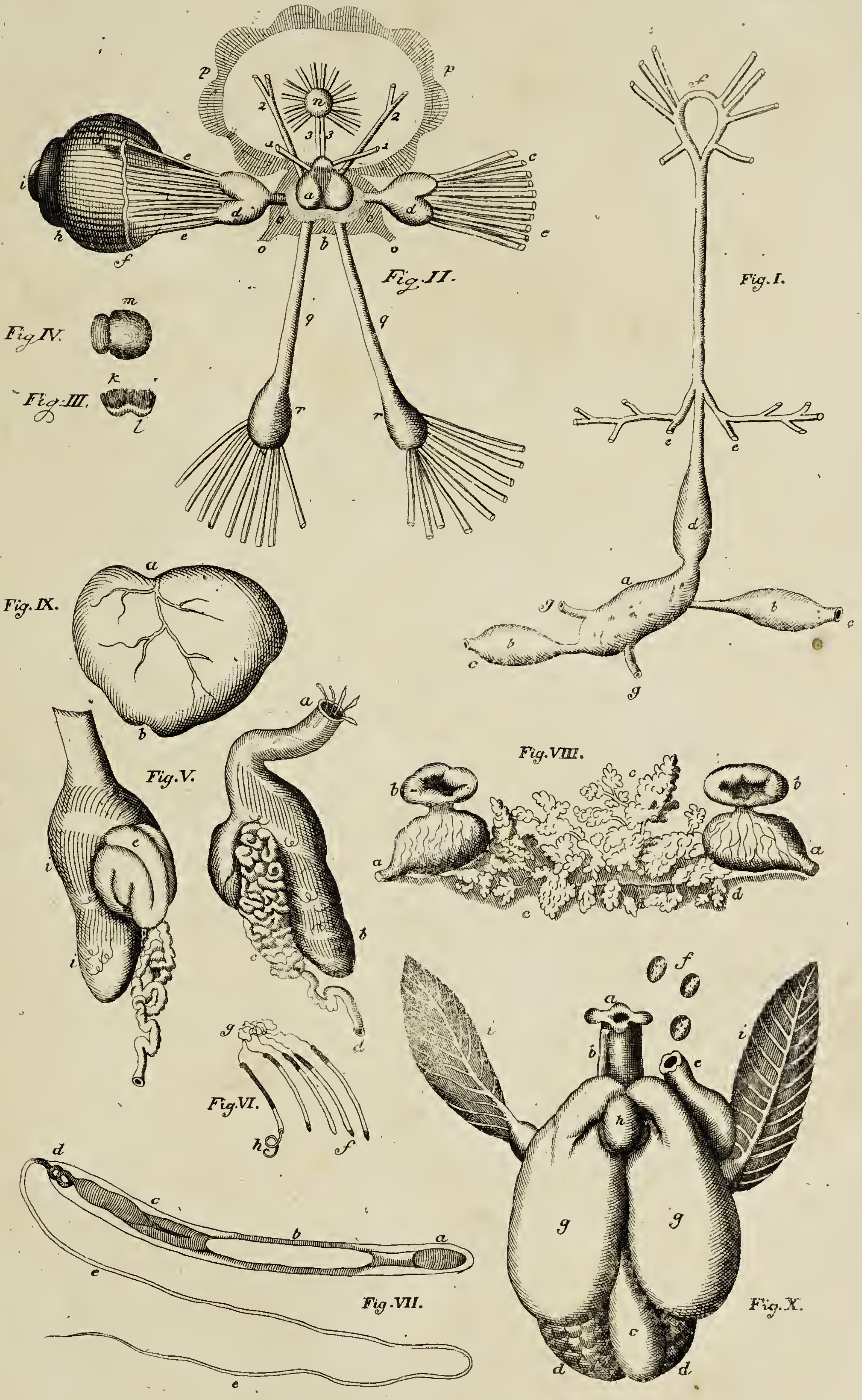
TAB: L.



TAB: IX.



TAB: LII.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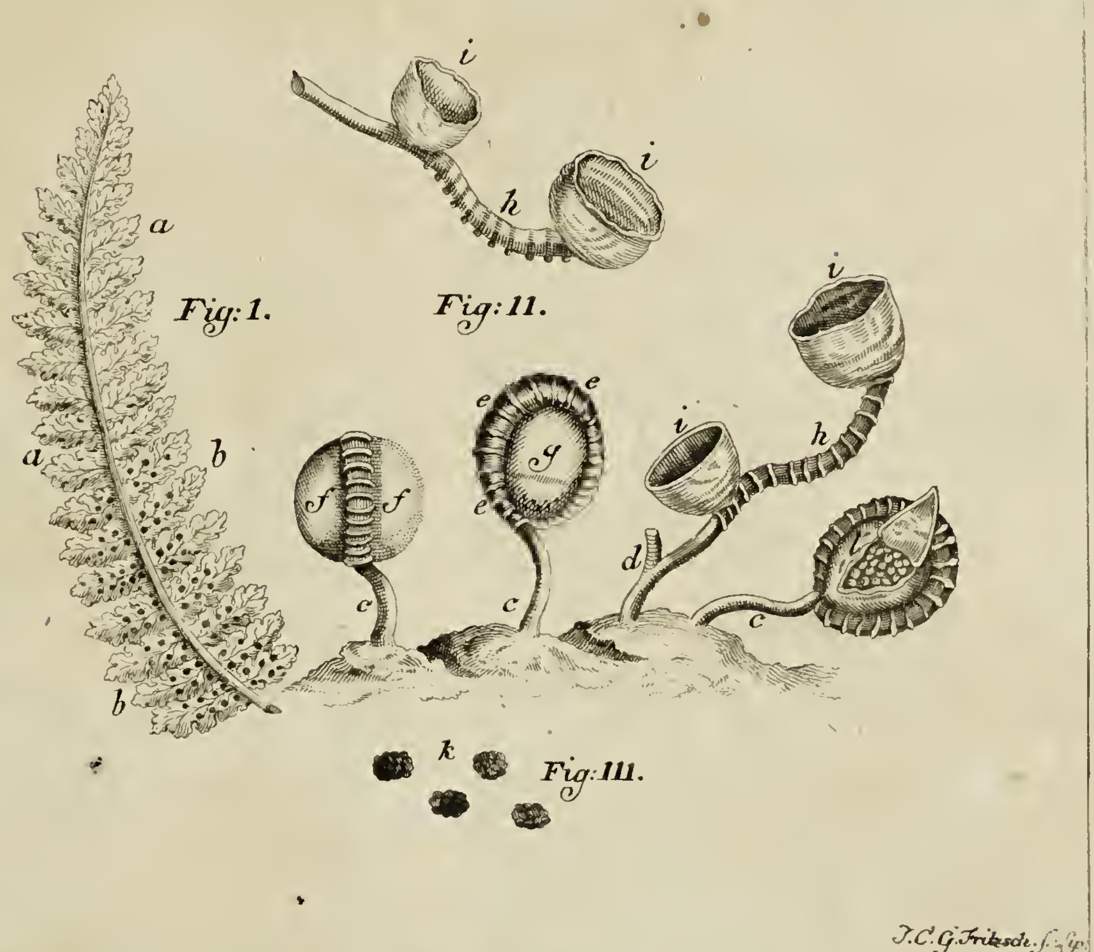
TAB: LIII.



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P. II. ſignifies Part the Second.

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T H E E N D.

The Reader is deſired to excuſe and correct the following ERRATA.

Page Col. Line	*Inſtead of*	*pleaſe to read*
31—2— 3	like a point	like a point *b*
32—1—44	of thoſe rings	of thoſe rings *f*
39—2—47	pidgeons	Pigeons.
46—2—34	ſtomach	ſtomach *b*
52—2—37	operculum	operculum Tab. IV. Fig. III. *m*
53—2—45	a little dilated,	a little dilated *g*
56—2—33	differens, which opens	defferens *b b* which opens
57—1—18	penis *e*	penis Fig. XX. *e*
60—1—54	the brain	the brain *c*
61— —44	bones	bone
63—1—45	Tab. IV.	Tab. VI.
65—2—29	halictations	habitations
67—1— 1	Stenon	Steno
—— —56	ſtretched out,	Stretched out *f*
69—1— 4	two upper ones	two upper *c c* ones
73—1— 8	divided ſkin	divided ſkin *c*
——2—10	tube	tube *z*
76—1—36	uterus	uterus *e*
77—2—31	ridge	ridge *b*
90—2—40	obſerved *b* ſeveral	obſerved ſeveral
98—1—50	Fig. I.	Fig. I. *a*
——2—11	wings	wings *d d*
100—2—54	Fig. VII.	Fig. VII. *a*
101— — 2	*belong*	*belongs*
102—1— 1	entraneous	extraneous
—— 2—48	middle *e*,	middle *c*,
104—1—29	1661	1671
108—1— 5	exuberant	extuberant
—— 2—21	Fig. IV.	Fig. IV. *f f*
109—2—58	this,	this *f*,
122—1—44	Panopes,	Panorpes,
132—1—51	Tab. XVII.	Tab. XXVII.
————40	varous	various
135—1—29	hairs,	hairs *f*,
136—1—37	Tab. XVII.	Tab. XXVII.
138—2— 8	the nerves	the nerves *d d d*
139—1—21	knot	knot *f*
140—1-laſt line but one	teeth	teeth *d d*
152—1—	after Fig. V. and VI.	blot out *b c* and *d*
163—1—7th line from the bottom	Delphos	Delft
P. II.		
11—1—33	head a	head and
53—1— 8	Hornius	Horne
141—1— 8	Stento	Steno
146—1—13	with	*l* with
149—2—26	fibres,	fibres *f*,

The Copper Plates are to be placed between the Explanation of the Tables and the Index.