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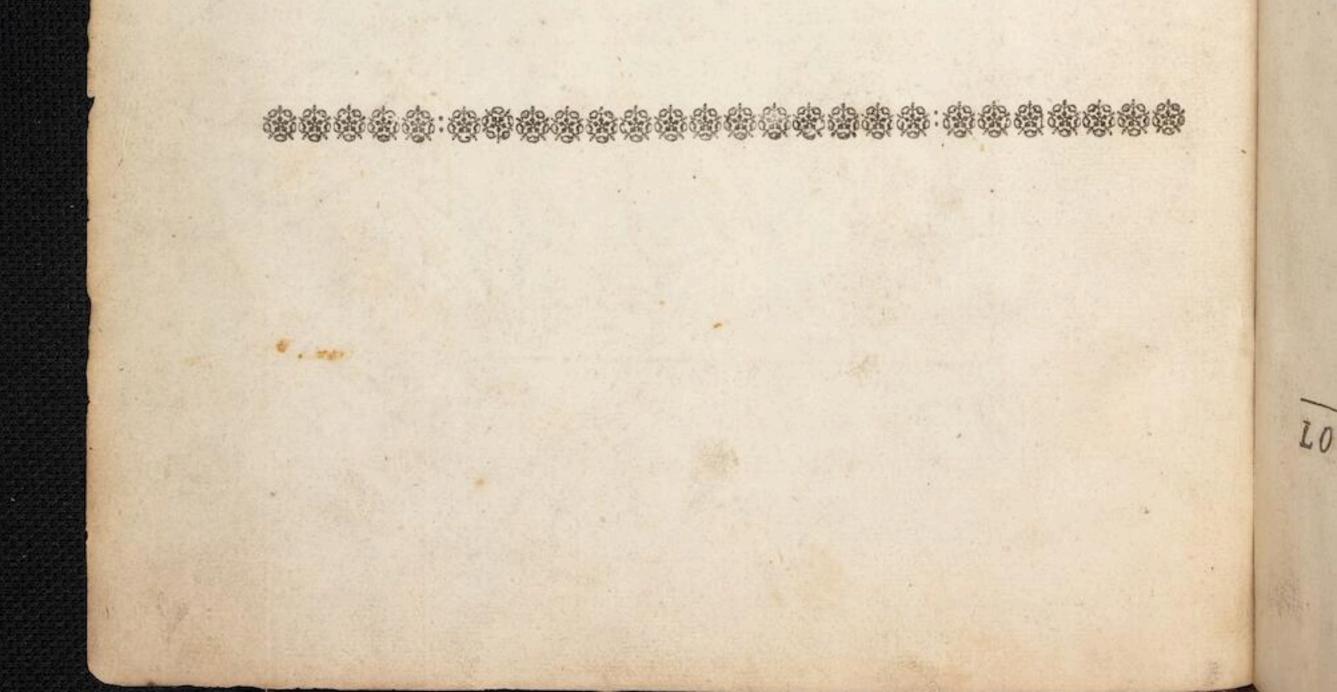
By the Council of the ROYAL SOCIETY of London for Improving of Natural Knowledge.

Ordered, That the Book written by Robert Hooke, M. A. Fellow of this Society, Entitled, Micrographia, or fome Phyfiological Deferiptions of Minute Bodies, made by Magnifying Glaffes, with Obfervations and Inquiries thereupon, Be Printed by John Martyn, and James Alleftry, Printers to the faid Society.

Novem. 23. 1664.

BROUNCKER. P.R.S.

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MICROGRAPHIA:

OR SOME Physiological Descriptions

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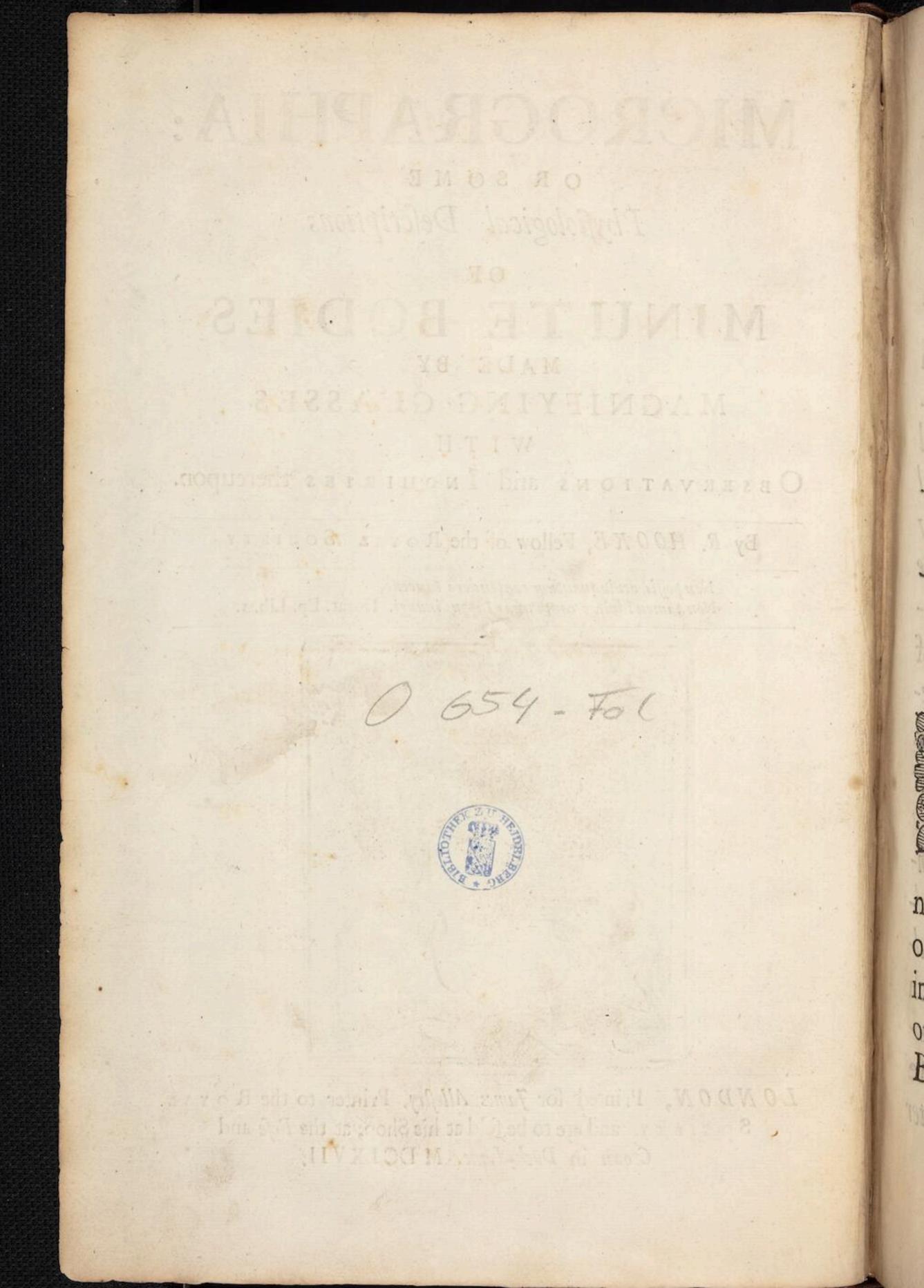
By R. HOOKE, Fellow of the ROYAL SOCIETY.

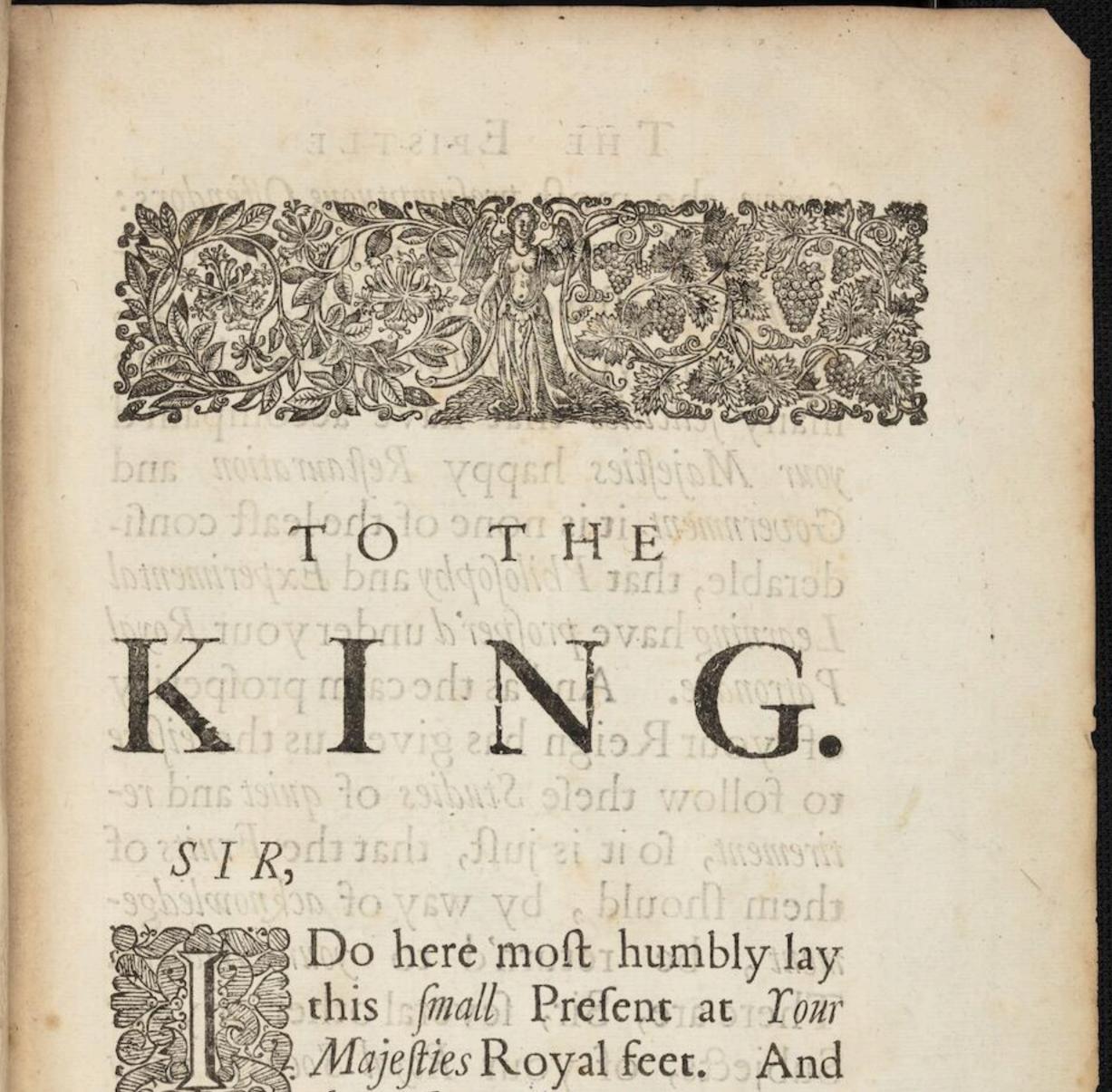
Non possis oculo quantum contendere Linceus, Non tamen idcirco contemnas Lippus inungi. Horat. Ep. Lib. 1.



Ausovici Fabriti, IFriderici Miegu

LONDON, Printed for James Allestry, Printer to the ROYAL SOCIETY, and are to be fold at his Shop, at the Rose and Crown in Duck-Lane. MDCLXVII.





though it comes accompany'd with two difadvantages, the meannefs of the Author, and of the Subject; yet in both I am incouraged by the greatnefs of your Mercy and your Knowledge. By the one I am taught, that you can A forgive

THE EPISTLE

forgive the most presumptuous Offendors: And by the other, that you will not esteem the least work of Nature, or Art, unworthy your Observation. Amidst the many felicities that have accompani'd your Majesties happy Restauration and Government, it is none of the least considerable, that Philosophy and Experimental Learning have prosper'd under your Royal Patronage. And as the calm prosperity of your Reign has given us the leisure to follow these Studies of quiet and retirement, soit is just, that the Fruits of them should, by way of acknowledgement, be return'd to your Majesty. There are, Sir, several other of your Subjects, of your Royal Society, now busie about Nobler matters : The Improvement of Manufactures and Agriculture, the Increase of Commerce, the Advantage of Navigation: In all which they are assisted by your Majesties Inconragement and Example. Amidst all those greater

DEDICATORY.

greater Defigns, I here prefume to bring in that which is more proportionable to the *smalnefs* of my Abilities, and to offer fome of the *least* of all visible things, to that Mighty King, that has establisht an Empie over the best of all Invisible things of this World, the Minds of Men.

added to chem fome Defriptions, and fome Capters of my own. And cherefore, together with YOUR development also beg YOUR pardon. The Rules YOU have prevented and filles in Your Majefties most bounded and grounded and confit and most bounded and store the bound of the filles which is any fear the store is some found on the freatile in which there to condern my own Confern the freatile in which the store of the Hallow Subject and Servant.

to have them underflood only as Canichares and Queries (which YOUR Method does not altogether difallow yet if even in thole I have exceeded, 'the fit that I thould declare, that is was not done by YOUR Directions. For it is moft unrectonable, that YOU fhould undergo the *imputation* of the 'faults of my Carjectures, feeing YOU can receive fo (mall advantage of reputaier is is \mathbf{N} is the 'faults of my Car-

TOUR most humble and most faithful Servasit ROBERT HOOKE.

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in that which is more proportionable to ROYAL/SOCIETY.



Fter my Address to our Great Founder and Patron, I could not but think my felf oblig'd, in confideration of those many Ingagements you have laid upon me, to offer these my poor Labours to this MOST ILLU-STRIOUS ASSEMBLY. YOU have been pleas'd formerly to accept of these rude Draughts. I have fince added to them some Descriptions, and some Conjectures of my own. And therefore, together with YOUR Acceptance, I must alfo beg YOUR pardon. The Rules YOU have prefcrib'd YOUR felves in YOUR Philosophical Progress do seem the best that have ever yet been practis'd. And particularly that of avoiding Dogmatizing, and the effoufal of any Hypothesis not sufficiently grounded and confirm'd by Experiments. This way feems the most excellent, and may preferve both Philosophy and Natural History from its former Corruptions. In faying which, I may feem to condemn my own Course in this Treatife ; in which there may perhaps be some Expressions, which may seem more positive then YOUR Prescriptions will permit : And though I defire to have them understood only as Conjectures and Quæries (which YOUR Method does not altogether difallow)yet if even in those I have exceeded, 'tis fit that I should declare, that it was not done by YOUR Directions. For it is most unreasonable, that YOU should undergo the imputation of the faults of my Conjectures, seeing YOU can receive so small advantage of reputation by the fleight Observations of

> YOUR most bumble and most faithful Servant

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ROBERT HOOKE.

THE PREFACE.



T is the great prerogative of Mankind above other Creatures, that we are not only able to behold the works of Nature, or barely to fuscin our lives by them, but we have also the power of confidering, comparing, altering, affifting, and improving

them to various uses. And as this is the peculiar priviledge of humane Nature in general, so is it capable of being so far advanced by the helps of Art, and Experience, as to make some Men excel others in their Observations, and Deductions, almost as much as they do Beasts. By the addition of such artificial Instruments and methods, there may be, in some manner, a reparation made for the mischiefs, and imperfection, mankind has drawn upon it self, by negligence, and intemperance, and a wilful and superstitious deserting the Prescripts and Rules of Nature, whereby every man, both from a deriv'd corruption, innate and born with him, and from his breeding and converse with men, is very subject to flip into all forts of errors.

The only way which now remains for us to recover fome degree of those former perfections, seems to be, by recitifying the operations of the Senfe, the Memory, and Reason, since upon the evidence, the strength, the integrity, and the right correspondence of all these, all the light, by which our actions are to be guided, is to be renewed, and all our command over things is to be establisht. It is therefore most worthy of our consideration, to recollect their seseveral defects, that so we may the better understand how to supply them, and by what als for we may inlarge their power, and secure them in performing their particular duties. As for the actions of our Senses, we cannot but observe them to be in

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many particulars much outdone by those of other Creatures, and when at best, to be far short of the perfection they seem capable of : And these infirmities of the Senses arise from a double cause, either from the disproportion of the Object to the Organ, whereby an infinite number of things can never enter into them, or else from error in the Perception, that many things, which come within their reach, are not received in a right manner.

The like frailties are to be found in the Memory ; we often let many things flip away from us, which deferve to be retain'd; and of those which we treasure up, a great part is either frivolous or false; and if good, and substantial, either in tract of time obliterated, or at best so overwhelmed and buried under more frothy notions, that when there is need of them, they are in vain sought for.

The two main foundations being so deceivable, it is no wonder, that all the succeeding works which we build upon them, of arguing, concluding defining judging, and all the other degrees of Reason, are lyable to the same imperfection, being, at best, either vain, or uncertain: So that the errors of the understanding are answerable to the two other, being defective both in the quantity and goodness of its knowledge; for the limits, to which our thoughts are confind, are finall in respect of the vast extent of Nature it self; some parts of it are too large to be comprehended, and some too little to be perceived. And from thence it must fallow, that not having a full sensation of the Object, we must be very lame and imperfect in our conceptions about it, and in all the propositions which we build upon it; hence we often take the shadow of things for the fubstance, fmall appearances for good fimilitudes, fimilitudes for definitions; and even many of those, which we think to be the most folid definitions, are rather expressions of our own misguided apprehenfions then of the true nature of the things themselves. The effects of these imperfections are manifested in different ways, according to the temper and diffosition of the several minds of men, fome they incline to gross ignorance and stupidity, and others to a prefumptuous imposing on other mens Opinions, and a confident dogmatizing on matters, whereof there is no affurance to be given. Thus

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Thus all the uncertainty, and miftakes of humane actions, proceed either from the narrownels and wandring of our Senfes, from the flipperinefs or delusion of our Memory, from the confinement or rashnels of our Understanding, so that 'tis no wonder, that our power over natural causes and effects is so flowly improved; seeing we are not only to contend with the obscurity and difficulty of the things whereon we work and think, but even the forces of our own minds conspire to betray us. These being the dangers in the process of humane Reason, the remedies of them all can only proceed from the real, the mechanical, the experimental Philosophy, which has this advantage over the Philosophy of discourse and disputation, that whereas that chiefly aims at the subtility of its Deductions and Conclusions, without much regard to the first ground-work, which ought to be well laid on the Sense and Memory; so this intends the right ordering of them all, and the making them ferviceable to each other.

The first thing to be undertaken in this weighty work, is a watchfulnels over the failings and an inlargement of the dominion, of the Senses.

To which end it is requifite, first, That there should be a scrupulous choice, and a strict examination, of the reality, constancy, and certainty of the Particulars that we admit: This is the first rife whereon truth is to begin, and here the most severe, and most impartial diligence, must be imployed; the storing up of all, without any regard to evidence or use, will only tend to darkness and consuston. We must not therefore esteem the riches of our Philosophical treasure by the number only, but chiefly by the weight; the most instructive are to be entertain'd; the footsteps of Nature are to be trac'd, not only in her ordinary course, but when the second be put to her shifts, to make many doublings and turnings, and to use some kind of art in indeavouring to avoid our difcovery.

The next care to be taken, in reffect of the Senfes, is a fupplying of their infirmities with Inftruments, and, as it were, the adding of artificial Organs to the natural; this in one of them has been of late years accom-

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The PREFACE.

accomplifies with prodigious benefit to all forts of ufeful knowledge, by the invention of Optical Glaffes. By the means of Telescopes, there is nothing fo far diftant but may be reprefented to our view; and by the belp of Microscopes, there is nothing fo small, as to escape our inquiry; hence there is a new visible World discovered to the understanding. By this means the Heavens are open'd, and a vast number of new Stars, and new Motions, and new Productions appear in them, to which all the antient Astronomers were utterly Strangers. By this the Earth it felf, which lyes so neer us, under our feet, shews quite a new thing to us, and in every little particle of its matter, we now behold almost as great a variety of Creatures, as we were able before to reckon up in the whole Universe it felf.

It feems not improbable, but that by these helps the subtility of the composition of Bodies, the structure of their parts, the various texture of their matter, the instruments and manner of their inward motions, and all the other possible appearances of things, may come to be more fully discovered; all which the antient Peripateticks were content to comprehend in two general and (unless further explained) useless words of Matter and Form. From whence there may arife many admirable advantages, towards the increase of the Operative, and the Mechanick Knowledge, to which this Age feems fo much inclined, becaufe we may perhaps be inabled to difcern all the fecret workings of Nature, almost in the same manner as we do those that are the productions of Art, and are manag'd by Wheels, and Engines, and Springs, that were devifed by humane Wit. In this kind I here present to the World my imperfect Indeavours ; which though they shall prove no other way confiderable, yet, I hope, they may be in some measure useful to the main Design of a reformation in Philosophy, if it be only by shewing, that there is not so much requir'd towards it, any strength of Imagination, or exactness of Method, or depth of Contemplation (though the addition of these, where they can be had, must needs produce a much more perfect composure) as a fincere Hand, and a faithful Eye, to examine, and to record, the things themselves. the material . this in one of their as they appear.

And I beg my Reader, to let me take the boldness to affure him, that in this prefent condition of knowledge, a man so qualified, as I have indeavoured to be, only with resolution, and integrity, and plain intentions of imploying his Senses aright, may venture to compare the reality and the usefulness of his services, towards the true Philosophy, with those of other men, that are of much stronger, and more acute speculations, that shall not make use of the same method by the Senses.

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The truth is, the Science of Nature has been already too long made only a work of the Brain and the Fancy : It is now high time that it fhould return to the plainness and foundness of Observations on material and obvious things. It is faid of great Empires, That the best way to preferve them from decay, is to bring them back to the first Principles, and Arts, on which they did begin. The fame is undoubtedly true in Philosophy, that by wandring far away into invifible Notions, has almost quite destroy'd it felf, and it can never be recovered, or continued, but by returning into the fame sensible paths, in which it did at first proceed.

If therefore the Reader expects from me any infallible Deductions, or certainty of Axioms, I am to fay for my felf, that those stronger Works of Wit and Imagination are above my weak Abilities; or if they had not been so, I would not have made use of them in this present Subject before me: Whereever he finds that I have ventur'd at any small Conjectures, at the causes of the things that I have observed, Ibeseech him to look upon them only as doubtful Problems, and uncertain ghesses, and not as unquessionable Conclusions, or matters of unconsutable Science; I have produced nothing here, with intent to bind his understanding to an implicit consent; I am so far from that, that I desire him, not absolutely to rely upon these Observations of my eyes, if he finds them contradicted by the future Ocular Experiments of sober and impartial Discoverers.

As for my part, I have obtained my end, if these my small Labours shall be thought fit to take up some place in the large slock of natural Observations, which so many hands are busie in providing. If I have contributed the meanest foundations whereon others may raise nobler b Super-

Superstructures, I am abundantly satisfied; and all my ambition is, that I may serve to the great Philosophers of this Age, as the makers and the grinders of my Glasses did to me; that I may prepare and furnish them with some Materials, which they may afterwards order and manage with better skill, and to far greater advantage.

The next remedies in this univerfal cure of the Mind are to be applyed to the Memory, and they are to confift of fuch Directions as may inform us, what things are best to be stor'd up for our purpose, and which is the best way of so disposing them, that they may not only be kept in fastery, but ready and convenient, to be at any time produc'd for use, as occasion shall require. But I will not here prevent my felf in what I may fay in another Discourse, wherein I shall make an attempt to propose some Considerations of the manner of compiling a Natural and Artificial History, and of so ranging and registring its Particulars into Philosophical Tables, as may make them most useful for the raising of Axioms and Theories.

The last indeed is the most hazardous Enterprize, and yet the most neceffary ; and that is, to take fuch care that the Judgment and the Reason of Man (which is the third Faculty to be repair'd and improv'd) (bould receive such assistance, as to avoid the dangers to which it is by nature most subject. The Imperfections, which I have already mention'd, to which it is lyable, do either belong to the extent, or the goodness of its knowledge; and here the difficulty is the greater, leaft that which may be thought a remedy for the one should prove destructive to the other, least by seeking to inlarge our Knowledge, we should render it weak and uncertain; and least by being too scrupulous and exact about every Circumstance of it, we should confine and streighten it too much. In both these the middle wayes are to be taken, nothing is to be omitted, and yet every thing to paß a mature deliberation : No Intelligence from Men of all Professions, and quarters of the World, to be flighted, and yet all to be fo feverely examin'd, that there remain no room for doubt or instability; much rigour in admitting, much strictness in comparing, and above all, much flowness in debating, and fhynels.

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shyness in determining, is to be practifed. The Understanding is to order all the inferiour services of the lower Faculties; but yet it is to do this only as a lawful Master, and not as a Tyrant. It must not incroach upon their Offices, nor take upon it self the employments which belong to either of them. It must watch the irregularities of the Senses, but it must not go before them, or prevent their information. It must examine, range, and dispose of the bank, which is laid up in the Memory : but it must be fure to make distinction between the sober and well collected heap, and the extravagant Idea's, and mistaken Images, which there it may fometimes light upon. So many are the links, upon which the true Philosophy depends, of which, if any one be loofe, or weak, the whole chain is in danger of being diffolu'd; it is to begin with the Hands and Eyes, and to proceed on through the Memory, to be continued by the Reason; nor is it to stop there, but to come about to the Hands and Eyes again, and fo, by a continual passage round from one Faculty to another, it is to be maintained in life and firength, as much as the body of man is by the circulation of the blood through the feveral parts of the body, the Arms, the Fat, the Lungs, the Heart, and the Head.

If once this method were followed with diligence and attention, there is nothing that lyes within the power of human Wit (or which is far more effectual) of human Industry, which we might not compass; we might not only hope for Inventions to equalize those of Copernicus, Galileo, Gilbert Harvy, and of others, whofe Names are almost lost, that were the Inventors of Gun-powder, the Seamans Compais, Printing, Etching, Graving, Microscopes, &c. but multitudes that may far exceed them : for even those discoveries seem to have been the products of some such method, though but imperfect ; What may not be therefore expected from it if thoroughly profecuted? Talking and contention of Arguments would foon be turn'd into labours; all the fine dreams of Opinions, and univerfal metaphyfical natures, which the luxury of fubtil Brains has devis'd, would quickly vanish, and give place to folid Histories, Experiments and Works. And as at first, mankind fell by tasting of the forbidden Tree of Knowledge, so we, their Posterity, may be in part restor'd by

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by the same way, not only by beholding and contemplating, but by tasting too those fruits of Natural knowledge, that were never yet forbidden.

From hence the World may be affifted with variety of Inventions, new matter for Sciences may be collected, the old improv'd, and their ruft rubb'd away; and as it is by the benefit of Senfes that we receive all our Skill in the works of Nature, fo they alfo may be wonderfully benefited by it, and may be guided to an eafier and more exact performance of their Offices; 'tis not unlikely, but that we may find out wherein our Senfes are deficient, and as eafily find wayes of repairing them.

The Indeavours of Skilful men have been most conversant about the affistance of the Eye, and many noble Productions have followed upon it; and from hence we may conclude, that there is a way open'd for advancing the operations, not only of all the other Senses, but even of the Eye it self; that which has been already done ought not to content us, but rather to incourage us to proceed further, and to attempt greater things in the same and different wayes.

'Tis not unlikely, but that there may be yet invented feveral other helps for the eye, as much exceeding those already found, as those do the bare eye, such as by which we may perhaps be able to discover living Creatures in the Moon, or other Planets, the figures of the compounding Particles of matter, and the particular Schematisms and Textures of Bodies.

And as Glaffes have highly promoted our feeing, so 'tis not improbable, but that there may be found many Mechanical Inventions to improve our other Senses, of hearing, smelling, tasting, touching. 'Tis not

impoffible to hear a whilper a furlongs diftance, it having been already done; and perhaps the nature of the thing would not make it more impoffible, though that furlong fhould be ten times multiply'd. And though fome famous Authors have affirm'd it impoffible to hear through the thinneft plate of Mulcovy-glafs; yet Iknow a way, by which tis eafie enough to hear one fpeak through a wall a yard thick. It has not been yet thoroughly examin'd, how far Otocoufticons may be improv'd, nor what other wayes there may be of quickning our hearing, or conveying found through other bodies then the Air: for that that is not the only medium, I can affure the Reader, that I have, by the help of a diftended wire, propagated

gated the found to a very confiderable diftance in an inftant, or with as feemingly quick a motion as that of light, at leaft, incomparably fwifter then that, which at the fame time was propagated through the Air; and this not only in a ftraight line, or direct; but in one bended in many angles.

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Nor are the other three so perfect, but that diligence, attention, and many mechanical contrivances, may also bighly improve them. For fince the sense of smelling seems to be made by the swife passage of the Air (impregnated with the fleams and effluvia of feveral odorous Bodies) through the grifly meanders of the Nofe whose furfaces are cover d with a very sensible nerve, and moistned by a transudation from the proceffus mamillares of the Brain, and fome adjoyning glandules, and by the moift fteam of the Lungs, with a Liquor convenient for the reception of those effluvia and by the adhesion and mixing of those steams with that liquor, and thereby affecting the nerve, or perhaps by infinuating themselves into the juices of the brain, after the (ame manner, as I have in the following Observations intimated, the parts of Salt to paß through the skins of Effs, and Frogs. Since, I fay, (melling feems to be made by fome fuch way, 'tis not improbable, but that fome contrivance, for making a great quantity of Air paß quick through the Nofe, might as much promote the fense of smelling, as the any wayes hindring that passage does dull and destroy it. Several tryals I have made, both of bindring and promoting this fense, and have succeeded in some according to expectation; and indeed to me it seems capable of being improv'd, for the. judging of the conftitutions of many Bodies. Perhaps we may thereby also judge (as other Creatures feem to do) what is wholfome, what poyfon ; and in a word, what are the specifick properties of Bodies. There may be also some other mechanical wayes found out, of sensibly perceiving the effluvia of Bodies; several Instances of which, were it here proper, I could give of Mineral fleams and exhalations; and it feems not imposible, but that by some such wayes improved, may be discovered, what Minerals lye buried under the Earth, without the trouble to dig for them; some things to confirm this Conjecture may be found in Agricola, and other Writers of Minerals, speaking of the Vegetables that are apt to thrive, or Whether pine, in those steams.

Whether also those steams, which seem to issue out of the Earth, and mix with the Air (and so to precipitate some aqueous Exhalations, wherewith 'tis impregnated) may not be by some way detected before they produce the effect, seems hard to determine; yet something of this kind I am able to discover, by an Instrument I contriv'd to shew all the minute variations in the pressure of the Air; by which I constantly find, that before, and during the time of rainy weather, the pressure of the Air is less, and in dry weather, but especially when an Eastern Wind (which having pass pass over vast tracts of Land is heavy with Earthy Particles) blows, it is much more, though these changes are varied according to very odd Laws.

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The Inftrument is this. I prepare a pretty capaceous Bolt-head AB, with a small stem about two foot and a half long DC; upon the end of this D I put on a small bended Glass, or brazen Syphon DEF (open at D, E and F, but to be closed with cement at F and E, as occasion ferves) whose stem F fhould be about fix or eight inches long, but the bore of it not above half an inch diameter, and very even; thefe I fix very ftrongly together by the help of very hard Cement, and then fit the whole Glass ABCDEF into a long Board, or Frame, in fuch manner, that almost half the head A B may lye buried in a concave Hemisphere cut into the Board RS; then I place it fo on the Board R S, as is exprest in the first Figure of the first Scheme; and fix it very firm and steady in that posture, fo as that the weight of the Mercury that is afterwards to be put into it, may not in the least shake or ftir it; then drawing a line XY on the Frame R T, fo that it may divide the ball into two equal parts, or that it may pass, as 'twere, through the center of the ball. 1 begin from that, and divide all the reft of the Board towards UT into inches, and the inches between the 25 and the end E(which need not be above two or three and thirty inches diftant from the line X Y) I fubdivide into Decimals; then stopping the end F with soft Cement, or soft Wax, I invert the Frame, placing the head downwards, and the Orifice E upwards; and by it, with a small Funnel, I fill the whole Glass with Quickfilver; then by ftopping the fmall Orifice E with my finger, I oftentimes erect and invert the whole Glafs and Frame, and thereby free the Quickfilver and Glafs from all the bubbles or parcels of lurking Air; then inverting it as before, I fill it top full with clear and well strain'd Quickfilver, and having made ready a small ball of pretty hard Cement, by heat made very fost, I press it into the hole E, and thereby ftop it very fast; and to secure this Cement from flying out afterward, I bind over it a piece of Leather, that is fpread over in the infide with Cement, and wound about it whilft the Cement is hot : Having thus fastned it, I gently erect again the Glass after this manner : I first let the Frame down edge-wayes, till the edge R V touch the Floor, or ly horizontal; and then in that edging posture raise the end RS; this I do, that if there chance to be any Air hidden in the fmall Pipe E, it may afcend into the Pipe F, and not into the Pipe DC: Having thus erected it, and hung it by the hole Q, or fixt it perpendicularly by any other means, I open the end F, and

and by a fmall Syphon I draw out the Mercury fo long, till I find the furface of it AB in the head to touch exactly the line XY; at which time I immediately take away the syphon, and if by chance it be run fomewhat below the line XY, by pouring in gently a little Mercury at F, Iraile it again to its defired height, by this contrivance I make all the fentible rifing and falling of the Mercury to be visible in the furface of the Mercury in the Pipe F, and fcarce any in the head A B. But becaufe there really is fome fmall change of the upper furface alfo, I find by feveral Obfervations how much it rifes in the Ball, and falls in the Pipe F, to make the diftance between the awo furfaces an inch greater then it was before ; and the measure that it falls in the Pipe is the length of the inch by which I am to mark the parts of the Tube F, or the Board on which it lyes, into inches and Decimals: Having thus justned and divided it, I have a large Wheel MNOP, whole outmost limb is divided into two hundred equal parts; this by certain small Pillars is fixt on the Frame R T, in the manner express in the Figure. In the middle of this, on the back fide, in a convenient frame, is placed a fmall Cylinder, whose circumference is equal to twice the length of one of those divisions, which I find answer to an inch of alcent, or descent, of Mercury: This Cylinder I, is movable on a very fmall Needle, on the end of which is fixt a very light Index K L, all which are fo pois'd on the Axis, or Needle, that no part is heavier then another : Then about this Cylinder is wound a fmall Clew of Silk, with two fmall fteel Bullets at each end of it GH; one of thefe, which is fomewhat the heavier, ought to be fo big, as freely to move to and fro in the PipeF; by means of which contrivance, every the least variation of the height of the Mercury will be made exceeding visible by the motion to and fro of the fmall Index KL.

But this is but one way of discovering the effluvia of the Earth mixt with the Air; there may be perhaps many others, witness the Hygroscope, an Instrument whereby the watery steams volatile in the Air are discerned, which the Nose it felf is not able to find. This I have described in the following Trast in the Description of the Beard of a wild Oat. Others there are, may be discovered both by the Nose, and by other wayes also. Thus the stop furning Wood is smelt, seen, and sufficiently set by the eyes: The sumes of burning Brimstone are smelt and discovered also by the destroying the Colours of Bodies, as by the whitening of a red Rose: And who knows, but that the Industry of man, following this method, may find out wayes of improving this sense to as great a degree of perfection as it is in any Animal, and perhaps yet higher.

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'Tis not improbable alfo, but that our tafte may be very much improv'd, either by preparing our taft for the Body, as, after eating bitter things, Wine, or other Vinous liquors, are more fenfibly tafted; or elfe by preparing

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paring Bodies for our taft; as the diffolving of Metals with acid Liquors, make them tafkable, which were before altogether infipid; thus Lead becomes fweeter then Sugar, and Silver more bitter then Gall, Copper and Iron of most loathfome tasts. And indeed the business of this sense being to discover the prefence of diffolved Bodies in Liquors put on the Tongue, or in general to discover that a fluid body has some folid body disfolv'd in it, and what they are; whatever contrivance makes this discovery improves this sense. In this kind the mixtures of Chymical Liquors afford many Instances; as the sweet Vinegar that is impregnated with Lead may be discovered to be so by the affusion of a little of an Alcalizate folution: The bitter liquor of Aqua fortis and Silver may be discover'd to be charg'd with that Metal, by laying in it fome plates of Copper: 'Tis not improbable also, but there may be multitudes of other wayes of discovering the parts discover diffolved in liquors; and what is this discovery but a kind of fecundary tasting.

'Tis not improbable alfo, but that the fense of feeling may be highly improv'd, for that being a sense that judges of the more gross and robust motions of the Particles of Bodies, seems capable of being improv'd and affisied very many wayes. Thus for the distinguishing of Heat and Cold, the Weather-glass and Thermometer, which I have defcrib'd in this following Treatife, do exceedingly perfect it; by each of which the leaft variations of heat or cold, which the most Acute sense is not able to distinguish, are manifested This is oftentimes further promoted also by the help of Burning-glaffes, and the like, which collect and unite the radiating heat. Thus the roughness and smoothness of a Body is made much more fensible by the help of a Microscope, then by the most tender and delicate Hand. Perhaps, a Physitian might, by several other tangible proprieties, discover the conflitution of a Body as well as by the Pulse. I do but instance in these, to shew what possibility there may be of many others, and what probability and hopes there were of finding them, if this method were followed ; for the Offices of the five Senses being to detect either the fubtil and curious Motions propagated through all pellucid or perfectly homogeneous Bodies; Or the more gross and vibrative Pulse communicated through the Air and all other convenient mediums, whether fluid or folid : Or the effluvia

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effluvia of Bodies diffolv'd in the Air; Or the particles of bodies diffolv'd or diffoluble in Liquors, or the more quick and violent fhaking motion of heat in all or any of thefe: whatfoever does any wayes promote any of thefe kinds of criteria, does afford a way of improving fome one fenfe. And what a multitude of thefe would a diligent Man meet with in his inquiries? And this for the helping and promoting the fenfitive faculty only.

Next, as for the Memory, or retentive faculty, we may be fufficiently infiructed from the written Hiltories of civil actions, what great affiftance may be afforded the Memory, in the committing to writing things obfervable in natural operations. If a Phyfitian be therefore accounted the more able in his Faculty, becaufe he has had long experience and practice, the remembrance of which, though perhaps very imperfect, does regulate all his after actions : What ought to be thought of that man, that has not only a perfect register of his own experience, but is grown old with the experience of many hundreds of years, and many thoufands of men.

And though of late, men, beginning to be sensible of this convenience, bave here and there registred and printed some few Centuries, yet for the most part they are set down very lamely and imperfectly, and, I fear, many times not fo truly, they feeming, feveral of them, to be defign'd more for Oftentation then publique use : For not to instance, that they do, for the most part, omit those Experiences they have made, wherein their Patients have miscarried, it is very easie to be perceiv'd, that they do all along hyperbolically extol their own Prescriptions, and vilifie those of others. Notwithfianding all which, these kinds of Histories are generally efteen duseful, even to the ablest Physitian. us, as we have over them by What may not be expected from the rational or deductive Faculty that is furnisht with such Materials, and those so readily adapted, and rang'd for use, that in a moment, as 'twere, thousands of Instances, serving for the illustration, determination, or invention, of almost any inquiry, may be represented even to the fight ? How neer the nature of Axioms must all those Propositions be which are examin'd before so many Witneffes? And how difficult will it be for any, though never fo subtil an error in Philosophy, to scape from being discover'd, after it has indur'd the touch, and fo many other tryals? What

What kind of mechanical way, and phylical invention also is there requir'd, that might not this way be found out? The Invention of a way to find the Longitude of places is easily perform'd, and that to as great perfection as is defir'd, or to as great an accurateness as the Latitude of places can be found at Sea; and perhaps yet also to a greater certainty then that has been bitberto found, as I shall very speedily freely manifest to the world. The way of flying in the Air seems principally unpracticable, by reason of the want of strength in humane muscles; if therefore that could be supplied, it were, I think, easie to make twenty contrivances to perform the office of Wings: What Attempts also I have made for the supplying that Defect, and my successes therein, which, I think, are wholly new, and not inconfiderable, I shall in another place relate.

'Tis not unlikely alfo, but that Chymifts, if they followed this method, might find out their fo much fought for Alkaheft. What an universal Menstruum, which diffolves all forts of Sulphureous Bodies, Ihave discover d (which has not been before taken notice of as such) Ibave shewn in the stateenth Observation.

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What a prodigious variety of Inventions in Anatomy has this latter Age afforded, even in our own Bodies, in the very Heart, by which we live, and the Brain, which is the feat of our knowledge of other things? witnes all the excellent Works of Pecquet, Bartholinus, Billius, and many others ; and at home, of Doctor Harvy, Doctor Ent, Doctor Willis, Doctor In Celestial Observations we have far exceeded all the An-Gliffon. tients, even the Chaldeans and Egyptians themselves, whose vast Plains, high Towers, and clear Air, did not give them fo great advantages over us, as we have over them by our Glaffes. By the help of which, they have been very much outdone by the famous Galileo, Hevelius, Zulichem; and our own Countrymen, Mr. Rook, Doctor Wren, and the great Ornament of our Church and Nation, the Lord Bishop of Exeter. And to fay no more in Aerial Discoveries, there has been a wonderful progress made by the Noble Engine of the most Illustrious Mr. Boyle, whom it becomes me to mention with all honour, not only as my particular Patron, but as the Patron of Philosophy it self; which he every day increases by his Labours, and adorns by his Example. Philodophy to lianc from Selever and o many other toyals?

The good success of all these great Men, and many others, and the now feemingly great obviousnels of most of their and divers other Inventions, which from the beginning of the world have been, as 'twere, trod on, and yet not minded till these last inquisitive Ages (an Argument that there may be yet behind multitudes of the like) puts me in mind to recommend fuch Studies, and the profecution of them by fuch methods, to the Gentlemen of our Nation, whose leifure makes them fit to undertake, and the plenty of their fortunes to accomplish, extraordinary things in this way. And I do not only propose this kind of Experimental Philosophy as a matter of high rapture and delight of the mind, but even as a material and fenfi-So vaft is the variety of Objects which will come under ble Pleafure. their Inflections, fo many different wayes there are of handling them, fo great is the fatisfaction of finding out new things, that I dare compare the contentment which they will injoy, not only to that of contemplation, but even to that which most men prefer of the very Senses themselves.

And if they will please to take any incouragement from so mean and so imperfect endeavours as mine, upon my own experience, I can asfure them, without arrogance, That there has not been any inquiry or Problem in Mechanicks, that I have bither to propounded to my felf, but by a certain method (which I may on some other opportunity explain) I have been able prefently to examine the possibility of it; and if so, as easily to excogitate divers wayes of performing it : And indeed it is possible to do as much by this method in Mechanicks, as by Algebra can be perform din Geometry. Nor can I at all doubt, but that the fame method is as applicable to Phyfical Enquiries, and as likely to find and reap thence as plentiful a crop of Inventions; and indeed there feems to be no subject fo barren, but may with this good husbandry be highly improv'd. Toward the profecution of this method in Physical Inquiries, I have bere and there gleaned up an handful of Observations, in the collection of most of which I made use of Microscopes, and some other Glasses and Instruments that improve the sense; which way I have herein taken, not that there are not multitudes of useful and pleasant Observables, yet uncolleEted, obvious enough without the helps of Art, but only to promote the use of Mechanical helps for the Senfes, both in the surveying the already visible World,

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The PREFACE.

World, and for the discovery of many others hitherto unknown, and to make us, with the great Conqueror, to be affected that we have not yet overcome one World when there are so many others to be discovered, every considerable improvement of Telescopes or Microscopes producing new Worlds and Terra-Incognita's to our view.

The Glasses I used were of our English make, but though very good of the kind, yet far short of what might be expected, could we once find a way of making Glasses Elliptical, or of some more true shape; for though both Microfcopes, and Telescopes, as they now are, will magnifie an Object about a thousand thousand times bigger then it appears to the naked eye; yet the Apertures of the Object-glasses are so very small that very few Rays are admitted, and even of those few there are so many false, that the Object appears dark and indiffinet : And indeed these inconveniences are such as feem inseparable from Spherical Glasses, even when most exactly made; but the way we have hitherto made use of for that purpose is so imperfect, that there may be perhaps ten wrought before one be made tolerably good, and most of those ten perhaps every one differing in goodness one from another, which is an Argument, that the way hitherto used is, at least, very uncertain. So that these Glasses have a double defect; the one, that very few of them are exactly true wrought; the other, that even of those that are best among them, none will admit a sufficient number of Rayes to magnifie the Object beyond a determinate bigness. Against which Inconveniences the only Remedies I have bitherto met with are thefe.

First, for Microscopes (where the Object we view is near and within our power)the beft way of making it appear bright in the Glassisto caft a great quantity of light on it by means of convex glaffes, for thereby, though the aperture be very fmall, yet there will throng in through it fuch multitudes, that an Object will by this means indure to be magnifi'd as much again as it would be without it. The way for doing which is this. I make choice of fome Room that has only one window open to the South, and at about three or four foot diftance from this Window, on a Table, I place my Microscope, and then so place either a round Globe of Water, or a very deep clear plano convex Glafs (whofe convex fide is turn'd towards the Window) that there is a great quantity of Rayes collected and thrown upon the Object : Or if the Sun shine, I place a small piece of oyly Paper very near the Object, between that and the light ; then with a good large Burning-Glass I fo collect and throw the Rayes on the Paper, that there may be a very great quantity of light pass through it to the Object ; yet I fo proportion that light, that it may

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may not finge or burn the Paper. Inftead of which Paper there may be made use of a fmall piece of Looking-glass plate, one of whose fides is made rough by being rubb'd on a flat Tool with very fine fand, this will, if the heat be leifurely caft on it, indure a much greater degree of heat, and confequently very much augment a convenient light. By all which means the light of the Sun, or of a Window, may be fo caft on an Object, as to make it twice as light as it would otherwise be without it, and that without any inconvenience of glaring, which the immediate light of the Sun is very apt to create in most Objects; for by this means the light is fo equally diffused, that all parts are alike inlightned; but when the immediate light of the Sun falls on it, the reflexions from fome few parts are fo vivid, that they drown the appearance of all the other, and are themselves also, by reason of the inequality of light, indiffinct, and appear only radiant spots.

But becaule the light of the Sun, and alfo that of a Window, is in a continual variation, and fo many Objects cannot be view'd long enough by them to be throughly examin'd; befides that, oftentimes the Weather is fo dark and cloudy, that for many dayes together nothing can be view'd: And becaufe alfo there are many Objects to be met with in the night, which cannot fo conveniently be kept perhaps till the day, therefore to procure and caft a fufficient quantity of light on an Object in the night, I thought of, and often ufed this, Expedient.

I procur'd me a small Pedestal, such as is describ'd in the fifth Figure of the first scheme on the small Pillar A B, of which were two movable Armes CD, which by means of the Screws EF, I could fix in any part of the Pillar; on the undermost of these I plac'd a pretty large Globe of Glass G, fill'd with exceeding clear Brine, ftopt, inverted, and fixt in the manner vifible in the Figure ; out of the fide of which Arm proceeded another Arm H, with many joynts; to the end of which was fastned a deep plain Convex glass I, which by means of this Arm could be moved to and fro, and fixt in any posture. On the upper Arm was placed a small Lamp K, which could be fo mov'd upon the end of the Arm, as to be fet in a fit posture to give light through the Ball: By means of this Inftrument duly plac'd, as is express in the Figure, with the small flame of a Lamp may be cast as great and convenient a light on the Object as it will well indure; and being always conftant, and to be had at any time. I found most proper for drawing the representations of those small Objects I had occasion to observe. None of all which ways (though much beyond any other hitherto made use of by any I know) do afford a sufficient help, but after a certain degree of magnifying, they leave us again in the lurch. Hence it were very defirable, that fome way were thought of for making the Object-glafs of fuch a Figure as would conveniently bear a large Aperture.

As for Telescopes, the only improvement they seem capable of, is the increasing of their length; for the Object being remote, there is no thought of giving it a greater light then it has; and therefore to augment the Aperture, the Glass must be ground of a very large sphere; for, by that

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means, the longer the Glaß be, the bigger aperture will it bear, if the Glasses be of an equal goodness in their kind. Therefore a fix will indure a much larger Aperture then a three foot Glaß; and a fixty foot Glaß will proportionably bear a greater Aperture then a thirty, and will as much excel it also as a fix foot does a three foot, as I have experimentally observ'd in one of that length made by Mr. Richard Reives here at London, which will bear an Aperture above three inches over, and yet make the Object proportionably big and diffinct; whereas there are very few thirty foot Glasses that will indure an Aperture of more then two inches over. So that for Telescopes, supposing we had a very ready way of making their Object Glasses of exactly spherical Surfaces, we might, by increasing the length of the Glass, magnifie the Object to any assignable bigneß. And for performing both thefe, I cannot imagine any way more eafie, and more exact, then by this following Engine, by means of which, any Glassof what length soever, may be speedily made. It seems the most easie, . because with one and the same Tool may be with care ground an Object Glaß, of any length or breadth requisite, and that with very little or no trouble in fitting the Engine, and without much skill in the Grinder. It seems to be the most exact, for to the very last stroke the Glass does regulate and rectifie the Tool to its exact Figure; and the longer or more the Tool and Glaß are wrought together, the more exact will both of them be of the defir'd Figure. Further, the motions of the Glaß and Tool do so croß each other, that there is not one point of eithers Surface, but has thousands of croß motions thwarting it, so that there can be no kind of Rings or Gutters made either in the Tool or Glaß.

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The contrivance of the Engine is, only to make the ends of two large *Mandrils* fo to move, that the Centers of them may be at any convenient diftance afunder, and that the *Axis* of the *Mandrils* lying both in the fame plain produc'd, may meet each other in any affignable Angle; both which requifites may be very well perform'd by the Engine defcrib'd in the third Figure of the first *Scheme*: where A B fignifies the Beam of a Lath fixt perpendicularly or Horizontally, CD the two Poppet heads, fixt at about two foot diftance, EF an Iron *Mandril*, whofe tapering neck F runs in an adapted tapering brafs Collar; the other end E runs on the point of a Screw G; in a convenient place of this is fasted H a pully Wheel, and into the end of it, that comes through the Poppet head C, is forewed a Ring of a hollow *Cylinder* K, or fome other conveniently fhap'd Tool, of what widenefs shall

be thought most proper for the cize of Glasses, about which it is to be imploy'd : As, for Object glasses, between twelve foot and an hundred foot long, the Ring may be about fix inches over, or indeed fomewhat more for those longer Glasses. It would be convenient also, and not very chargeable, to have four or five feveral Tools; as one for all Glaffes between an inch and a foot, one for all Glasses between a foot and ten foot long, another for all between ten and an hundred, a fourth for all between a hundred and a thousand foot long; and if Curiofity shall ever proceed for far, one for all lengths between a thousand and ten thousand foot long; forindeed the principle is fuch, that fuppofing the Mandrils well made, and of a good length, and supposing great care be used in working and polishing them, I fee no reason, but that a Glass of a thousand, nay of ten thousand foot long, may be as well made as one of ten; for the reason is the same, supposing the Mandrils and Tools be made fufficiently strong, so that they cannot bend; and supposing the Glass, out of which they are wrought, be capable of fo great a regularity in its parts as to refraction: this hollow Cylinder K is to contain the Sand, and by being drove round very quick to and fro by means of a fmall Wheel, which may be mov'd with ones foot, ferves to grind the Glafs : The other Mandril is shap'd like this, but it has an even neck instead of a taper one, and runs in a Collar, that by the help of a Screw, and a joynt made like M in the Figure, it can be still adjustned to the wearing or wasting neck : into the end of this Mandril is screwed a Chock N, on which with Cement or Glew is fastned the piece of Glass Q that is to be form'd; the middle of which Glass is to be plac'd just on the edge of the Ring, and the Lath OP is to be fet and fixt (by means of certain pieces and fcrews, the manner whereof will be fufficiently evidenc'd by the Figure) in fuch an Angle as is requisite to the forming of such a Sphere as the Glass is defign'd to be of; the geometrical ground of which being fufficiently plain, though not heeded before, I shall, for brevities fake, pass over. This last Mandrilis to be made (by means of the former, or fome other Wheel) to run round very swift also, by which two cross motions the Glass cannot chuse (if care be us'd) but be wrought into a most exactly spherical Surface.

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But becaufe we are certain, from the Laws of refraction (which I I have experimentally found to be fo, by an Inftrument I fhall prefently defcribe) that the lines of the angles of Incidence are proportionate to the lines of the angles of Refraction, therefore if Glasses could be made of those kind of Figures, or some other, such as the most incomparable Des Cartes has invented, and demonstrated in his Philosophical and Mathematical Works, we might hope for a much greater perfection of Opticks then can be rationally expected from spherical ones; for though, cæteris paribus, we find, that the larger the Telescope Object Glasses are, and the shorter those of the Microscope, the better they magnifie, yet both of them, beside

befide fuch determinate dimensions, are by certain inconveniences rendred unuseful; for it will be exceeding difficult to make and manage a Tube above an hundred foot long, and it will be as difficult to inlighten an Object less then an hundred part of an inch distant from the Object Glass.

I have not as yet made any attempts of that kind, though I know two or three wayes, which, as far as I have yet confidered, feem very probable, and may invite me to make a tryal as foon as I have an opportunity, of which I may hereafter perhaps acquaint the world. In the Interim, I fhall defcribe the Inftrument I even now mention'd, by which the refraction of all kinds of Liquors may be most exactly measur'd, thereby to give the curious an opportunity of making what further tryals of that kind they shall think requisite to any of their intended tryals; and to let them fee that the laws of Refraction are not only notional.

The Inftrument confifted of five Rulers, or long pieces placed together, after the manner exprest in the second Figure of the first scheme, where A B denotes a straight piece of wood about fix foot and two inches long, about three inches over, and an inch and half thick, on the back fide of which washung a fmall plummet by a line ftretcht from top to bottom, by which this piece was fet exactly upright, and fo very firmly fixt; in the middle of this was made a hole or center, into which one end of a hollow cylindrical brafs Box CC, fashion'd as I shall by and by describe, was plac'd, and could very eafily and truly be mov'd to and fro ; the other end of this Box being put into, and moving in, a hole made in a fmall arm DD; into this box was fastned the long Ruler EF, about three foot and three or four inches long, and at three foot from the above mention'd Centers P P was a hole E, cut through, and crofs'd with two fmall threads, and at the end of it was fixt a fmall fight G, and on the back fide of it was fixt a fmall Arm H, with a Screw to fix it in any place on the Ruler LM; this Ruler LM was mov'd on the Center B (which was exactly three foot diftance from the middle Center P) and a line drawn through the middle of it LM, was divided by a Line of cords into fome fixty degrees, and each degree was fubdivided into minutes, fo that putting the crofs of the threads in E upon any part of this divided line, I prefently knew what Angle the two Rules AB and EF made with each other, and by turning the Screw in H, I could fix them in any polition. The other Ruler also RS was made much after the fame manner, only it was not fixt to the hollow cylindrical Box, but, by means of two small brass Armes or Ears, it mov'd on the Centers of it; this also, by means of the crofs threads in the hole S, and by a Screw in K, could be fastned on any division of another line of cords of the same radius drawn on NO. And fo by that means, the Angle made by the two Rulers, AB and R S, was also known. The Brass box CC in the middle was shap'd very. much like the Figure X, that is, it was a cylindrical Box ftopp'd close at either end, off of which a part both of the fides and bottomes was cut out, fo that

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that the Box, when the Pipe and that was joyne d to it, would contain the Water when fill'd half full, and would likewife, without running over, indure to be inclin'd to an Angle, equal to that of the greatest refraction of Water, and no more, without running over. The Ruler E F was fixt very fast to the Pipe V, fo that the Pipe V directed the length of the RulerE F, and the Box and Ruler were mov'd on the Pin TT, fo as to make any defirable Angle with the Ruler A B. The bottom of this Pipe V was ftop'd with a fmall piece of exactly plain Glafs, which was plac'd exactly perpendicular to the Line of direction, or Axis of the Ruler EF. The Pins alfo T T were drill'd with fmall holes through the Axis, and through those holes was stretcht and fastned a small Wire. There was likewise a small Pipe of Tin loofly put on upon the end of V, and reaching down to the fight G; the use of which was only to keep any falle Rayes of light from paffing through the bottom of V, and only admitting fuch to pafs as pierced through the fight G: All things being placed together in the manner defcrib'd in the Figure ; that is, the Ruler A B being fixt perpendicular, I fill'd the Box CC with Water, or any other Liquor, whole refraction I intended to try, till the Wire passing through the middle of it were just covered : then I moved and fixt the Ruler F E at any affignable Angle, and placed the flame of a Candle just against the fight G; and looking through the fight I, I moved the Ruler R S to and fro, till I perceived the light paffing through G to be covered, as 'twere, or divided by the dark Wire paffing through PP: then turning the Screw in K, I fixt it in that posture: And through the hole S, I observed what degree and part of it was cut by the cross threads in S. And this gave me the Angle of Inclination, APS answering to the Angle of Refraction BPE : for the furface of the Liquor in the Box will be alwayes horizontal, and confequently AB will be a perpendicular to it; the Angle therefore APS will measure, or be the Angle of Inclination in the Liquor ; next E P B must be the Angle of Refraction, for the Ray that paffes through the fight G, paffes also perpendicularly through the Glass Diaphragme at F, and confequently also perpendicularly through the lower furface of the Liquor contiguous to the Glafs, and therefore suffers no refraction till it meet with the horizontal surface of the Liquor in CC, which is determined by the two Angles. By means of this Instrument I can with little trouble, and a very small quantity of any Liquor, examine, most accurately, the refraction of it, not only for one inclination, but for all; and thereby am inabled to make very accurate Tables; several of which I have also experimentally made, and find, that Oyl of Turpentine has a much greater Refraction. then Spirit of Wine, though it be lighter; and that Spirit of Wine has a greater Refraction then Water, though it be lighter alfo; but that falt Water alfo has a greater Refraction then fresh, though it be heavier ? but Allum water has a lefs refraction then common Water, though heal vier alfo. So that it seems, as to the refraction made in a Liquor, the specifick

fick gravity is of no efficacy. By this I have also found, that look what proportion the Sine of the Angle of one Inclination has to the Sine of the Angle of Refraction, correspondent to it, the same proportion have all the Sines of other Inclinations to the Sines of their appropriate Refractions.

My way for measuring how much a Glass magnifies an Object, plac'd at a convenient distance from my eye, is this. Having rectifi'd the *Microfcope*, to fee the defir'd Object through it very distinctly, at the same time that I look upon the Object through the Glass with one eye, I look upon other Objects at the same distance with my other bare eye; by which means I am able, by the help of a *Ruler* divided into inches and small parts, and laid on the *Pedestal* of the *Microfcope*, to cast, as it were, the magnifi'd appearance of the Object upon the Ruler, and thereby exactly to measure the Diameter it appears of through the Glass, which being compar'd with the Diameter it appears of to the naked eye, will easily afford the quantity of its magnifying.

The Microscope, which for the most part I made use of, was shap'd much like that in the fixth Figure of the first scheme, the Tube being for the most part not above fix or feven inches long, though, by reafon it had four Drawers, it could very much be lengthened, as occasion required; this was contriv'd with three Glasses a small Object Glass at A, a thinner Eye Glass about B, and a very deep one about C: this I made use of only when I had occafion to see much of an Object at once; the middle Glass conveying a very great company of radiating Pencils, which would go another way, and throwing them upon the deep Eye Glass. But when ever I had occasion to examine the small parts of a Body more accurately, I took out the middle Glass, and only made use of one Eye Glass with the Object Glass, for always the fewer the Refractions are, the more bright and clear the Object appears. And therefore 'tis not to be doubted, but could we make a Microscope to have one only refraction, it would, ceteris paribus, far excel any other that had a greater number. And hence it is, that if you take a very clear piece of a broken Venice Glass, and in a Lamp draw it out into very small hairs or threads, then holding the ends of these threads in the flame, till they melt and run into a fmall round Globul, or drop, which will hang at the end of the thread; and if further you flick feveral of these upon the end of a flick with a little fealing Wax, fo as that the threads frand upwards, and then on a Whetftone firft grind off a good part of them, and afterward on a fmooth. Metal plate, with a little Tripoly, rub them till they come to be very fmooth; if one of these be fixt with a little fost Wax against a small needle hole, prick'd through a thin Plate of Brafs, Lead, Pewter, or any other Metal, and an Object, plac'd very near, be look'd at through it, it will both magnifie and make fome Objects more diffinct then any of the great Micro-Scopes. But because these, though exceeding easily made, are yet very troublefome to be us'd, becaufe of their fmalnefs, and the nearnefs of the Object ; therefore to prevent both thefe, and yet have only two Refractions, I provided me a Tube of Brafs, fhap'd much like that in the fourth Figure of the first Scheme; into the smaller end of this I fixt with Wax a good plano con-

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vex Object Glaß, with the convex fide towards the Object, and into the bigger end I fixt alfo with wax a pretty large plano *Convex* Glaß, with the *convex* fide towards my eye, then by means of the fmall hole by the fide, I fill'd the intermediate fpace between thefe two Glaffes with very clear Water, and with a Screw ftopp'd it in; then putting on a Cell for the Eye, I could perceive an Object more bright then I could when the intermediate fpace was only fill'd with Air, but this, for other inconveniences, I made but little use of.

My way for fixing both the Glafs and Object to the Pedeftal moft conveniently was thus: Upon one fide of a round Pedeftal A B, in the fixth Figure of the first *scheme*, was fixt a fmall Pillar C C, on this was fitted a fmall Iron Arm D, which could be mov'd up and down, and fixt in any part of the Pillar, by means of a fmall Screw E; on the end of this Arm was a fmall Ball fitted into a kind of focket F, made in the fide of the BrafsRing G, through which the fmall end of the Tube was ferew'd; by means of which contrivance I could place and fix the Tube in what pofture I defir'd (which for many Obfervations was exceeding neceffary) and adjusten it most exactly to any Object.

For placing the Object, I made this contrivance; upon the end of a fmall brafs Link or Staple H H, I fo faftned a round Plate I I, that it might be turn'd round upon its Center K, and going pretty ftiff, would ftand fixt in any pofture it wasfet; on the fide of this was fixt a fmall Pillar P, about three quarters of an inch high, and through the top of this was thruft a fmall Iron pin M, whofe top juft ftood over the Center of the Plate; on this top I fixt a fmall Object, and by means of thefe contrivances I was able to turn it into all kind of pofitions, both to my Eye and the Light; for by moving round the fmall Plate on its center, I could move it one way, and by turning the Pin M, I could move it another way, and this without ftirring the Glafs at all, or at leaft but very little: the Plate likewife I could move to and fro to any part of the Pedeftal (which in many cafes was very convenient) and fix it alfo in any Pofition, by means of a Nut N, which was fcrew'd on upon the lower part of the Pillar CC. All the other Contrivances are obvious enough from the draught, and will need no defeription

Now though this were the Infirument I made most use of, yet I have made several other Tryals with other kinds of Microscopes, which both for matter and form were very different from common spherical Glasses. I have made a Microscope with one piece of Glass, both whose surfaces were plains. I have made another only with a plano concave, without any kind of reflection, divers also by means of reflection. I have made others of Waters, Gums, Refins, Salts, Arsenick, Oyls, and with divers other mixtures of watery and oyly Liquors. And indeed the subject is capable of a great variety; but I find generally none more useful then that which is made with two Glasses, such as I have already describ d. What

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What the things are I observ'd, the following descriptions will manifest; in brief, they were either exceeding small Bodies, or exceeding small Pores, or exceeding small Motions, some of each of which the Reader will find in the following Notes, and such, as I presume, (many of them at least) will be new, and perhaps not less strange: Some specimen of each of which Heads the Reader will find in the subsequent delineations, and indeed of some more then I was willing there should be; which was occasioned by my first Intentions to print a much greater number then I have since found time to compleat. Of such therefore as I had, I selected only some few of every Head, which for some particulars seen'd most obfervable, rejecting the rest as superfluous to the present Design.

What each of the delineated Subjects are, the following descriptions annext to each will inform, of which I shall here, only once for all, add, That in divers of them the Gravers have pretty well follow'd my directions and draughts; and that in making of them, I indeavoured (as far as I was able) first to discover the true appearance, and next to make a plain representation of it. This Imention the rather, because of these kind of Objects there is much more difficulty to discover the true shape, then of those visible to the naked eye, the same Object seeming quite differing, in one position to the Light, from what it really is, and may be discover'd in another. And therefore I never began to make any draught before by many examinations in several lights, and in several positions to those lights, I had discover'd the true form. For it is exceeding difficult in some Objects, to distinguish between a prominency and a depression, between a shadow and a black stain, or a reflection and a whiteness in the colour. Besides, the transparency of most Objects renders them yet much more difficult then if they were opacous. The Eyes of a Fly in one kind of light appear almost like a Lattice, drill'd through with abundance of small holes ; which probably may be the Reason, why the Ingenious Dr. Power seems to suppose them such. In the Sunshine they look like a Surface cover'd with golden Nails; in another posture, like a Surface cover'd with Pyramids; in another with Cones; and in other pofures of quite other shapes; but that which exhibits the best, is the Light collected on the Object, by those means I have already describ'd.

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And this was undertaken in profecution of the Defign which the ROY-AL SOCIETY has propos'd to it felf. For the Members of the Affembly having before their eys so many fatal Instances of the errors and falshoods, in which the greateft part of mankind has fo long wandred, becaufe they rely dupon the strength of humane Reason alone, have begun anew to correct all Hypotheses by sense, as Seamen do their dead Reckonings by Coelestial Observations; and to this purpose it has been their principal indeavour to enlarge & strengthen the Senses by Medicine, and by fuch outward Instruments as are proper for their particular works. By this means they find some reason to suffect, that those effects of Bodies, which have been commonly attributed to Qualities, and those confess'd to be occult, are perform'd by the small Machines of Nature, which are not to be difcern'd without these helps, feeming the meer products of Motion, Figure, and Magnitude; and that the Natural Textures, which some call the Plastick faculty, may be made in Looms, which a greater perfection of Opticks may make difcernable by these Glasses; so as now they are no more puzzled about them, then the vulgar are to conceive, how Tapestry or flowred Stuffs are woven. And the ends of all these Inquiries they intend to be the Pleasure of Contemplative minds, but above all, the ease and dispatch of the labours of mens hands. They do indeed neglect no opportunity to bring all the rare things of Remote Countries within the compaß of their knowledge and practice. But they still acknowledg their most uleful Informations to arife from common things, and from diverfifying their most ordinary operations upon them. They do not wholly reject Experiments of meer light and theory; but they principally aim at fuch, whole Applications will improve and facilitate the present way of Manual Arts. And though fome men, who are perhaps taken up about less honourable Employments, are pleas'd to censure their proceedings, yet they can shew more fruits of their first three years, wherein they have affembled, then any other Society in Europe can for a much larger fpace of time. Tis true, fuch undertakings as theirs do commonly meet with small incour agement, because men are generally rather taken with the plaufible and discursive, then the real and the folid part of Philosophy; yet by the good fortune of their institution, in an Age of all others the most inquisitive, they have been assisted by the contribution and prefence of very many of the chief Nobility and Gentry,

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and others, who are fome of the most confiderable in their feveral Professions. But that that yet farther convinces me of the Real efteem that the more ferious part of men have of this Society, is, that feveral Merchants, men who act in earneft (whose Object is meum & tuum, that great Rudder of humane affairs) have adventur'd confiderable sums of Money, to put in practice what some of our Members have contrived, and have continued stedfast in their good opinions of such Indeavours, when not one of a hundred of the vulgar have believed their undertakings feasable. And it is also fit to be added, that they have one advantage peculiar to themselves, that very many of their number are men of Converse and Traffick; which is a good Omen, that their attempts will bring Philosophy from words to action, seeing the men of Business have had so great a star in their first foundation.

And of this kind I ought not to conceal one particular Generofity, which more nearly concerns my felf. It is the munificence of Sir JohnCutler, in endowing a Lecture for the promotion of Mechanick Arts, to be governed and directed by This Society. This Bounty I mention for the Honourableness of the thing it felf, and for the expectation which I have of the efficacy of the Example ; for it cannot now be objected to them, that their Designs will be esteemed frivolous and vain, when they have fuch a real Testimony of the Approbation of a Man that is fuch an eminent Ornament of this renowned City, and one, who, by the Variety, and the happy Success, of his negotiations, has given evident proofs, that he is not easie to be deceiv'd. This Gentleman has well observ'd, that the Arts of life have been too long imprison'd in the dark. (bops of Mechanicks themselves, & there hindred from growth, either by ignorance, or felf-interest; and he has bravely freed them from these inconveniences: He hath not only obliged Tradesmen, but Trade it self: He has done a work that is worthy of London, and has taught the chief City of Commerce in the world the right way how Commerce is to be improv'd. We have already seen many other great signs of Liberality and a large mind, from the same hand: For by his diligence about the Corporation for the Poor; by his honorable Subscriptions for the rebuilding of St. Paul's; by his chearful Disburfment for the replanting of Ireland, and by many other fuch publick works, he has shewn by what means he indeavours to establish his Memory; and now by this last gift he has done that, which became one of the wifest Citizens

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of our Nation to accomplish, seeing one of the wifest of our Statesmen, the Lord Verulam, first propounded it.

But to return to my Subject, from a digression, which, I hope, my Reader will pardon me, seeing the Example is fo rare that I can make no more such If these my first Labours shall be any wayes useful to inquidigressions. ring men, I must attribute the incour agement and promotion of them to a very Reverend and Learned Perfon, of whom this ought in justice to be faid, That there is fearce any one Invention, which this Nation has produc'd in our Age, but it has fome way or other been fet forward by his affiftance. My Reader, I believe, will quickly gheß, that it is Dr. Wilkins that I mean. He is indeed a man born for the good of mankind, and for the honour of his Country. In the fweetness of whose behaviour, in the calmness of his mind, in the unbounded goodness of his heart, we have an evident Inflance, what the true and the primitive unpaffionate Religion was, before it was fowred by particular Factions. In a word, his Zeal has been fo constant and effectual in advancing all good and profitable Arts, that as one of the Antient Romans faid of Scipio, That he thanked God that he was a Roman ; becaufe whereever Scipio had been born, there had been the feat of the Empire of the world: So may I thank. God, that Dr. Wilkins was an Englishman, for whereever he had lived, there had been the chief Seat of generous Knowledge and true Philosophy. To the truth of this, there are fo many worthy men living that will fubferibe, that I am confident, what I have here faid, will not be look'd upon, by any ingenious Reader, as a Panegyrick, but only as a real tefti-

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By the Advice of this Excellent man I first fet upon this Enterprise, yet fill came to it with much Reluctancy, because I was to follow the footsteps of so eminent a Person as Dr. Wren, who was the first that attempted any thing of this nature; whose original draughts do now make one of the Ornaments of that great Collection of Rarities in the Kings Closet. This Honor, which his first beginnings of this kind have receiv'd, to be admitted into the most famous place of the world, did not so much incourage, as the hazard of coming after Dr. Wren did affright me; for of him I must affirm, that, fince the time of Archimedes, there scarce ever met in one man, in so great

great a perfection, such a Mechanical Hand, and so Philosophical a Mind.

But at last, being affur ed both by Dr. Wilkins, and Dr. Wren hinself, that he had given over his intentions of profecuting it, and not finding that there was any elfe design'd the pursuing of it, I set upon this undertaking, and was not a little incourag'd to proceed in it, by the Honour the Royal Society was pleas'd to favour me with, in approving of those draughts (which from time to time as I had an opportunity of describing) I presented to them. And particularly by the Incitements of divers of those Noble and excellent Perfons of it, which were my more especial Friends, who were not less urgent with me for the publishing, then for the profecution of them.

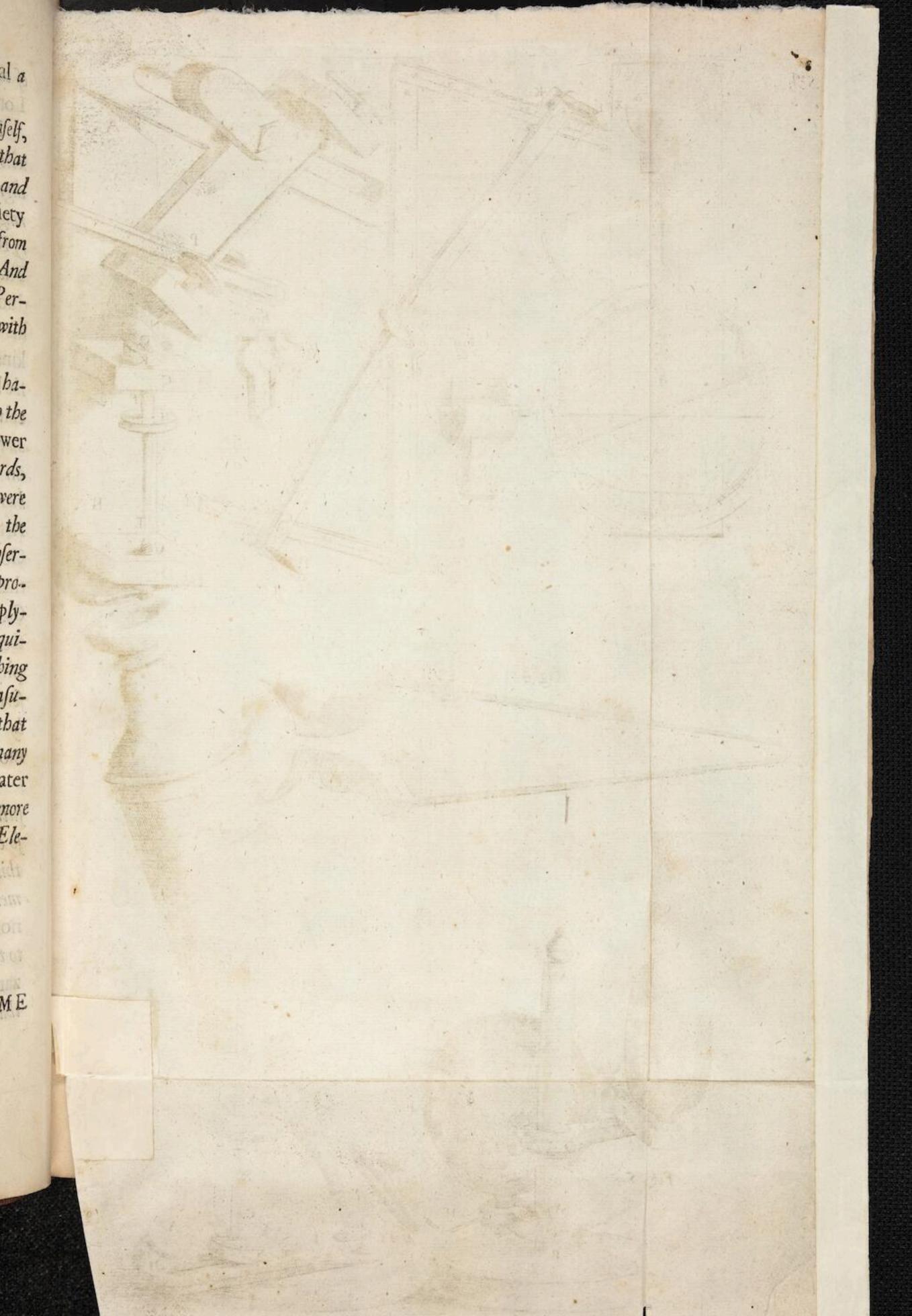
After I had almost compleated these Pictures and Observations (having had divers of them ingraven, and was ready to fend them to the Pres) I was informid, that the Ingenious Phylitian Dr. Henry Power had made feveral Microscopical Observations, which had I not afterwards, upon our interchangably viewing each others Papers, found that they were for the most part differing from mine, either in the Subject it felf, or in the particulars taken notice of; and that his defign was only to print Obfervations without Pictures, I had even then suppressed what I had so far proceeded in. But being further excited by feveral of my Friends, in complyance with their opinions, that it would not be unacceptable to feveral inquifitive Men, and hoping alfo, that I should thereby discover something New to the World, I have at length caft in my Mite, into the vaft Treafury of A Philosophical History. And it is my hope, as well as belief, that these my Labours will be no more comparable to the Productions of many other Natural Philosophers, who are now every where busie about greater things ; then my little Objects are to be compar'd to the greater and more beautiful Works of Nature, A Flea, a Mite, a Gnat, to an Horfe, an Elephant, or a Lyon. ments of that orent Collebian of Ravines in the Kings Clofer. The Ho-

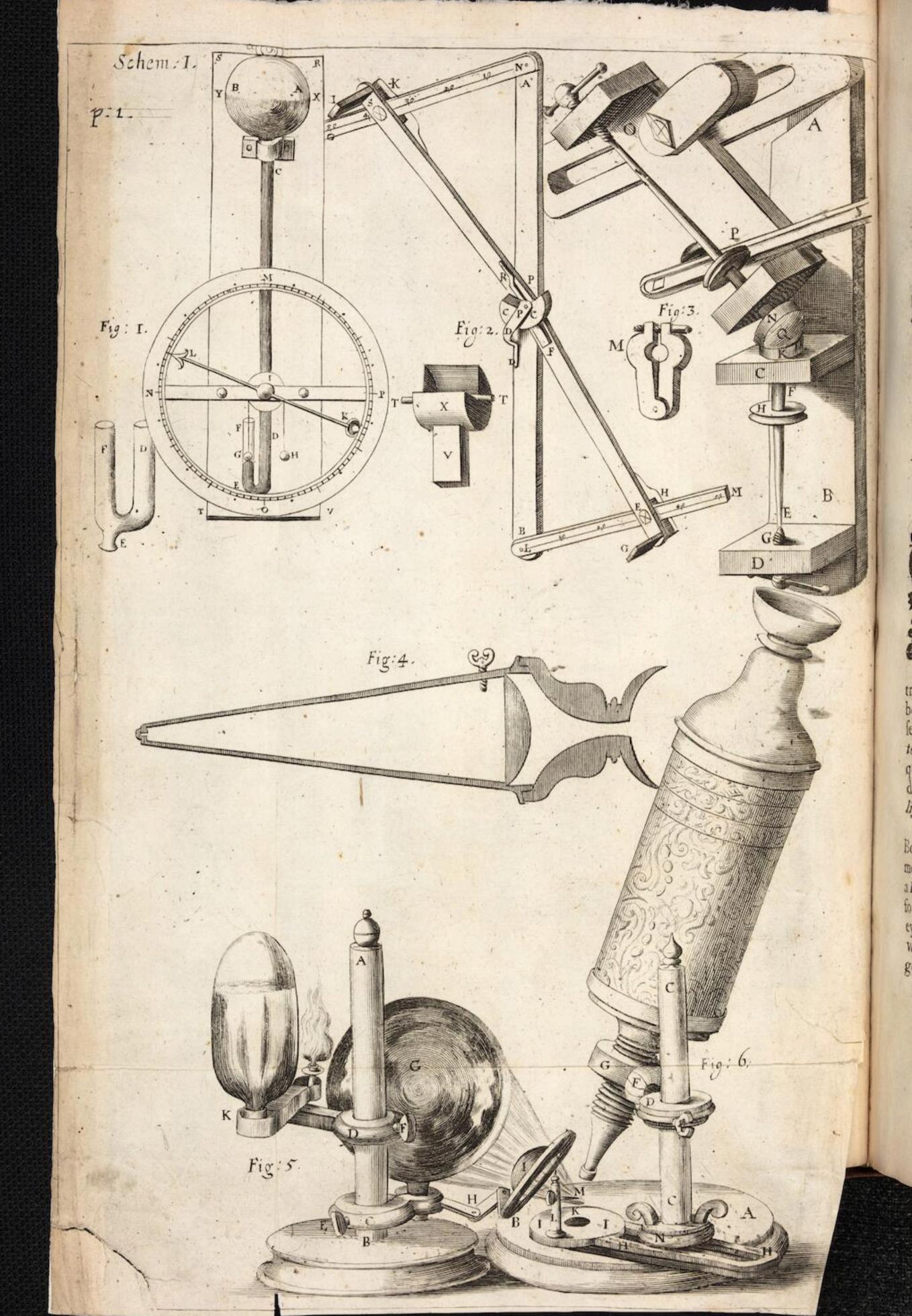
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OR SOME Phyfiological Defcriptions OF MINUTE BODIES, MADE BY MAGNIFYING GLASSES; WITH

OBSERVATIONS and INQUIRIES thereupon.

Observ. I. Of the Point of a sharp small Needle.



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S in Geometry, the most natural way of beginning is Schem.2; from a Mathematical point; fo is the fame method in Fig.1. Observations and Natural history the most genuine, fimple, and instructive. We must first endevour to make letters, and draw fingle strokes true, before we venture to write whole Sentences, or to draw large Pitures. And in Physical Enquiries, we must endevour

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to follow Nature in the more plain and easie ways she treads in the most *limple* and *uncompounded bodies*, to trace her steps, and be acquainted with her manner of walking there, before we venture our felves into the multitude of *meanders* she has in *bodies of a more complica-*

ted nature; left, being unable to diftinguish and judge of our way, we quickly lose both Nature our Guide, and our felves too, and are left to wander in the labyrinth of groundless opinions; wanting both judgment, that light, and experience, that clew, which should direct our proceedings.

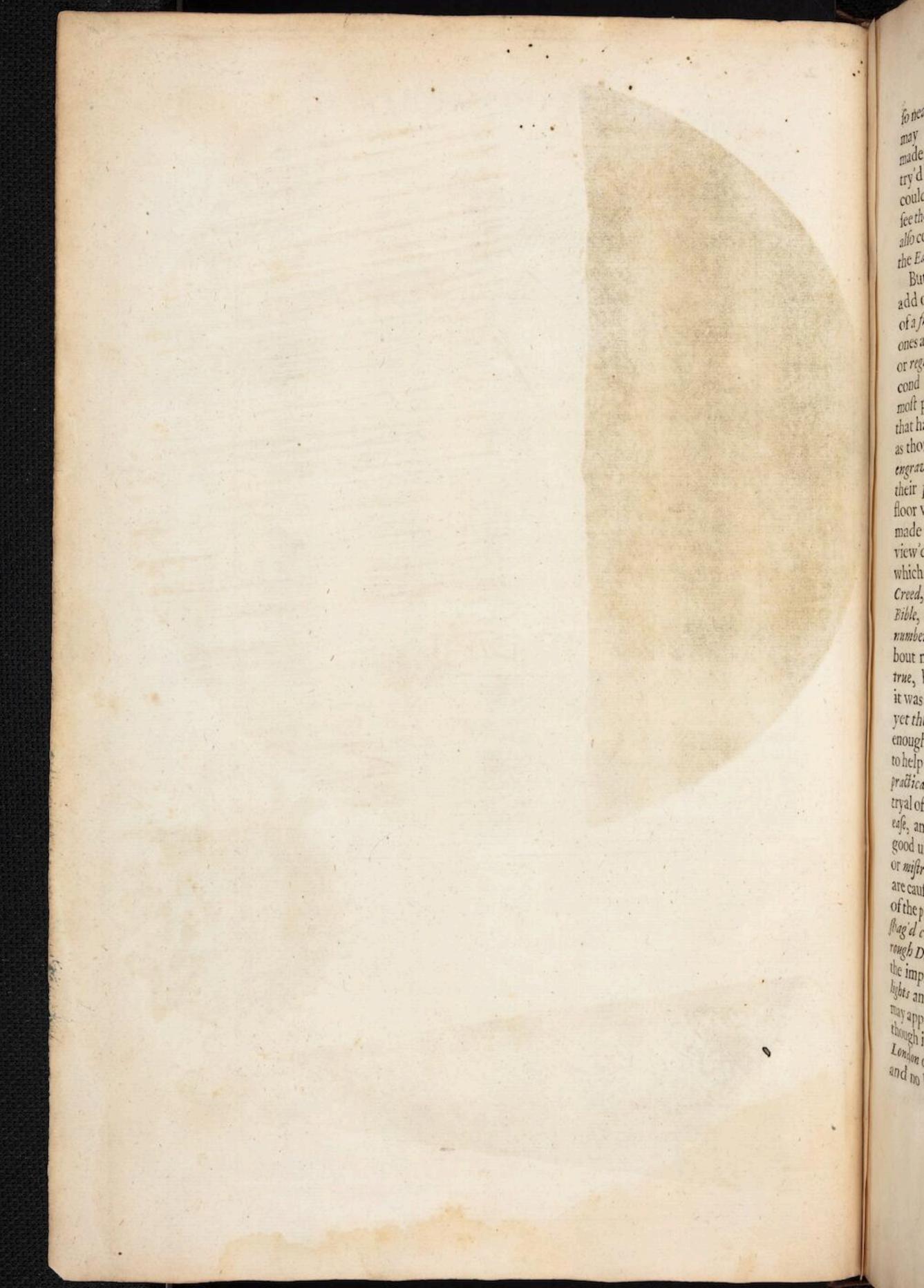
We will begin these our Inquiries therefore with the Observations of Bodies of the most *fimple nature* first, and so gradually proceed to those of a more *compounded* one. In profecution of which method, we shall begin with a *Physical point*; of which kind the *Point of a Needle* is commonly reckon'd for one; and is indeed, for the most part, made so that the naked eye cannot diftinguish any parts of it: It very eafily pierces, and makes its way through all kind of bodies softer then it softs us if view'd with a very good *Microscope*, we may find that the *top* of a Needle (though as to the B fense

fenfe very *fharp*) appears a *broad,blunt*, and very *irregular* end; not refembling a Cone, as is imagin'd, but onely a piece of a tapering body, with a great part of the top remov'd, or deficient. The Points of Pins are yet more blunt, and the Points of the most curious Mathematital Instruments do very feldome arrive at fo great a fharpness; how much therefore can be built upon demonstrations made onely by the productions of the Ruler and Compasse, he will be better able to confider that shall but view those points and lines with a Microscope.

Now though this point be commonly accounted the fharpeft (whence when we would express the fharpness of a point the most *fuperlatively*, we fay, As fharp as a Needle) yet the *Microfcope* can afford us hundreds of Inftances of Points many thousand times fharper: fuch as those of the *hairs*, and *briftles*, and *claws* of multitudes of *Infects*; the *thorns*, or *crooks*, or *hairs* of *leaves*, and other fmall vegetables; nay, the ends of the *ftiriæ* or fmall *parallelipipeds* of *Amianthus*, and *alumen plumofum*; of many of which, though the Points are fo fharp as not to be vitible, though view'd with a *Microfcope* (which magnifies the Object, in bulk, above a million of times) yet I doubt not, but were we able *practically* to make *Microfcopes* according to the *theory* of them, we might find hills, and dales, and pores, and a fufficient bredth, or expansion, to give all those parts elbow-room, even in the blunt top of the veryPoint of any of these for very fharp bodies. For certainly the *quantity* or extension of any body may be *Divisible in infinitum*, though perhaps not the *matter*.

But to proceed: The Image we have here exhibited in the first Figure, was the top of a small and very sharp Needle, whose point a a nevertheless appear'd through the Microscope above a quarter of an inch broad, not round nor flat, but irregular and uneven; fo that it feem'd to have been big enough to have afforded a hundred armed Mites room enough to be rang'd by each other without endangering the breaking one anothers necks, by being thrust off on either fide. The furface of which, though appearing to the naked eye very fmooth, could not neverthelefs hide a multitude of holes and fcratches and ruggedneffes from being discover'd by the Microscope to invest it, several of which inequalities (as A, B, C, feem'd holes made by fome fmall specks of Ruft; and D fome adventitious body, that fluck very close to it) were cafual. All the reft that roughen the furface, were onely fo many marks of the rudeness and bungling of Art. So unaccurate is it, in all its productions, even in those which seem most neat, that if examin'd with an organ more acute then that by which they were made, the more we fee of their *shape*, the lefs appearance will there be of their *beauty* : whereas in the works of Nature, the deepeft Difcoveries fhew us the greateft Excellencies. An evident Argument, that he that was the Author of all thefe things, was no other then Omnipotent ; being able to include as great a variety of parts and contrivances in the yet smallest Discernable Point, as in those vaster bodies (which comparatively are called also Points) such as the Earth, Sun, or Planets. Nor need it feem strange that the Earth it felf may be by an Analogie call'd a'Physical Point: For as its body, though now 10





fo near us as to fill our eys and fancies with a fense of the vastness of it, may by a little Distance, and some convenient *Diminishing* Glasses, be made vanish into a scarce visible Speck, or Point (as I have often try'd on the *Moon*, and (when not too bright) on the *Sun* it felf.) So, could a Mechanical contrivance successfully answer our *Theory*, we might see the least spot as big as the Earth it felf; and Discover, as *Des Cartes Diop* ch. also conjectures, as great a variety of bodies in the *Moon*, or *Planets*, as in ¹⁰. §9. the *Earth*.

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But leaving these Discoveries to future Industries, we shall proceed to add one Observation more of a point commonly fo call'd, that is, the mark of a full stop, or period. And for this purpose I observed many both printed ones and written ; and among multitudes I found few of them more round or regular then this which I have delineated in the third figure of the fecond Scheme, but very many abundantly more disfigur'd; and for the most part if they seem'd equally round to the eye, I found those points that had been made by a Copper-plate, and Roll-prefs, to be as misshapen as those which had been made with Types, the most curious and smothly engraven strokes and points, looking but as fo many furrows and holes, and their printed impressions, but like smutty daubings on a matt or uneven floor with a blunt extinguisht brand or stick's end. And as for points made with a pen they were much more rugged and deformed. Nay, having view'd certain pieces of exceeding curious writing of the kind (one of which in the bredth of a two-pence compris'd the Lords prayer, the Apostles Creed, the ten Commandments, and about half a dozen verses besides of the Bible, whose lines were so small and near together, that I was unable to number them with my naked eye, a very ordinary Microfcope, I had then about me, inabled me to fee that what the Writer of it had afferted was true, but withall discover'd of what pitifull bungling scribbles and scrawls it was compos'd, Arabian and China characters being almost as well shap'd ; yet thus much I must fay for the Man, that it was for the most part legible enough, though in fome places there wanted a good fantly well prepofeft to help one through. If this manner of small writing were made easie and practicable (and I think I know fuch a one, but have never yet made tryal of it, whereby one might be inabled to write a great deale with much eafe, and accurately enough in a very little roome) it might be of very good use to convey secret Intelligence without any danger of Discovery or mistrusting. But to come again to the point. The Irregularities of it are caufed by three or four coadjutors, one of which is, the uneven surface of the paper, which at best appears no smother then a very course piece of shag'd cloth, next the irregularity of the Type or Ingraving, and a third is the rough Daubing of the Printing-Ink that lies upon the inftrument that makes the impreffion, to all which, add the variation made by the Different lights and shadows, and you may have fufficient reason to ghess that a point may appear much more ugly then this, which I have here prefented, which though it appear'd through the Microscope gray, like a great splatch of London dirt, about three inches over; yet to the naked eye it was black; and no bigger then that in the midst of the Circle A. And could I have found

found Room in this Plate to have inferted an O you should have seen that the letters were not more distinct then the points of Distinction, nor a drawn circle more exactly fo, then we have now fhown a point to be a point.

Observ. II. Of the Edge of a Razor.

Fig. 2.

Schem.2. He fharpest Edge hath the fame kind of affinity to the sharpest Point in Phyficks, as a line hath to a point in Mathematicks; and therefore the Treaty concerning this, may very properly be annexed to the former. A Razor doth appear to be a Body of a very neat and curious afpect, till more closely viewed by the Microfcope, and there we may obferve its very Edge to be of all kind of shapes, except what it should be. For examining that of a very fharp one, I could not find that any part of it had any thing of sharpness in it; but it appear'd a rough surface of a very confiderable bredth from fide to fide, the narrowest part not feeming thinner then the back of a pretty thick Knife. Nor is't likely that it should appear any otherwife, fince as we just now shew'd that a point appear'd a circle, 'tis rational a line should be a parallelogram.

Now for the drawing this fecond Figure (which reprefents a part of the Edge about half a quarter of an inch long of a Razor well fet) I fo plac'd it between the Object-glass & the light, that there appear'd a reflection from the very Edge, represented by the white line abcdef. In which you may perceive it to be fomewhat fharper then elfewhere about d, to be indented or pitted about b, to be broader and thicker about c, and unequal and rugged about e, and pretty even between a b and ef. Nor was that part of the Edge g h i k fo fmooth as one would imagine fo fmooth bodies as a Hone and Oyl should leave it ; for befides those multitudes of fcratches, which appear to have raz'd the furface g h i k, and to crois each other every way which are not half of them exprest in the Figure, there were feveral great and deep fcratches, or furrows, fuch as g b and ik, which made the furface yet more rugged, caus'd perhaps by fome fmall Duft cafually falling on the Hone, or fome harder or more flinty part of the Hone it felf. The other part of the Razor 11, which is polifh'd on a grinding-ftone, appear'd much rougher then the other, looking almost like a plow'd field, with many parallels, ridges, and furrows, and a cloddy, as 'twere, or an uneven furface : nor fhall we wonder at the roughnefles of those furfaces, fince even in the most curious wrought Glasses for Microscopes, and other Optical uses, I have, when the Sun has shone well on them, discover'd their surface to be variously raz'd or fcratched, and to confift of an infinite of small broken furfaces, which refle& the light of very various and differing colours. And indeed it feems impoffible by Art to cut the furface of any hard and brittle body fmcoth, fince Putte, or even the most curious Powder that can be made use of, to polifh fuch a body, must confist of little hard rough particles, and each of them must cut its way, and consequently leave some kind of gutter or furrows

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furrow behind it. And though Nature does feem to do it very readily in all kinds of fluid bodies, yet perhaps future observators may discover even these also rugged; it being very probable, as I elsewhere shew, that fluid bodies are made up of small folid particles variously and strongly mov'd, and may find reason to think there is scarce a surface in rerum natura perfectly smooth. The black spot mn, I ghess to be some small fpeck of ruft, for that I have oft obferv'd to be the manner of the working of Corrofive Juyces. To conclude, this Edge and piece of a Razor, if it had been really fuch as it appear'd through the Microfcope, would fcarcely have ferv'd to cleave wood, much lefs to have cut off the hair of beards, unless it were after the manner that Lucian merrily relates Charon to have made use of, when with a Carpenters Axe he chop'd off the beard of a fage Philosopher, whose gravity he very cautiously fear'd would indanger the overfetting of his Wherry.

Observ. III. Of fine Lawn, or Linnen Cloth.

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THis is another product of Art, A piece of the finest Lawn I was able Schem. 15. to get, fo curious that the threads were fearce difeernable by the naked eye, and yet through an ordinary Microscope you may perceive what a goodly piece of coarse Matting it is 3 what proportionable cords each of its threads are, being not unlike, both in shape and fize, the bigger and coarfer kind of fingle Rope-yarn, wherewith they usually make Cables. That which makes the Lawn fo transparent, is by the Microscope, nay by the naked eye, if attentively viewed, plainly enough evidenced to be the multitude of square holes which are left between the threads, appearing to have much more hole in respect of the intercurrent parts then is for the most part left in a lattice-window, which it does a little refemble, onely the croffing parts are round and not flat.

These threads that compose this fine contexture, though they are as fmall as those that constitute the finer forts of Silks, have notwithstanding nothing of their gloffie, pleafant, and lively reflection. Nay, I have been informed both by the Inventor himfelf, and feveral other eye-witneffes, that though the flax, out of which it is made, has been (by a fingular art, of that excellent Perfon, and Noble Vertuofo, M. Charls Howard, brother to the Duke of Norfolk) fo curioufly drefs'd and prepar'd, as to appear both to the eye and the touch, full as fine and as gloffie, and to receive all kinds of colours, as well as Sleave-Silk ; yet when this Silken Flax is twifted into threads, it quite loseth its former luster, and becomes as plain and base a thread to look on, as one of the fame bignefs, made of common Flax. The reason of which odd Phenomenon seems no other then this; that though the curioufly dreft Flax has its parts fo exceedingly fmall, as to equallize, if not to be much fmaller then the clew of the Silk-worm, efpecially in thinnefs, yet the differences between the figures of the conftituting filaments are fo great, and their fubstances fo various, that whereas

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those of the silk are small, round, hard, transparent, and to their bigness proportionably stiff, fo as each filament preferves its proper Figure, and confequently its vivid reflection intire, though twifted into a thread, if not too hard; those of Flax are flat, limber, softer, and less transparent, and in twifting into a thread they joyn, and lie fo close together, as to lose their own, and deftroy each others particular reflections. There feems therefore three Particulars very requisite to make the fo dreft Flax appear Silk alfo when fpun into threads. First, that the substance of it should be made more clear and transparent, Flax retaining in it a kind of opacating brown, or yellow; and the parts of the whiteft kind I have yet observ'd with the Microscope appearing white, like flaw'd Horn or Glafs, rather then clear, like clear Horn or Glass. Next that, the filaments should each of them be rounded, if that could be done, which yet is not fo very neceffary, if the first be perform'd, and this third, which is, that each of the small filaments be stifned; for though they be square, or flat, provided they be transparent and stiff, much the same appearances must necessarily follow. Now, though I have not yet made trial, yet I doubt not, but that both these proprieties may be also induc'd upon the Flax, and perhaps too by one and the fame Expedient, which fome trials may quickly inform any ingenious attempter of, who from the use and profit of such an Invention, may find fufficient argument to be prompted to fuch Inquiries. As for the tenacity of the substance of Flax, out of which the thread is made, it feems much inferiour to that of Silk, the one being a vegetable, the other an animal fubstance. And whether it proceed from the better concoction, or the more homogeneous conftitution of animal fubftances above those of vegetables, I do not here determine; yet fince I generally find, that vegetable substances do not equalize the tenacity of animal, nor these the tenacity of some purified mineral substances; I am very apt to think, that the tenacity of bodies does not proceed from the hamous, or hooked particles, as the Epicureans, and fome modern Philofophers have imagin'd; but from the more exact congruity of the constituent parts, which are contiguous to each other, and fo bulky, as not to be eafily feparated, or fhatter'd, by any fmall pulls or concuffion of heat.

Fig: 3

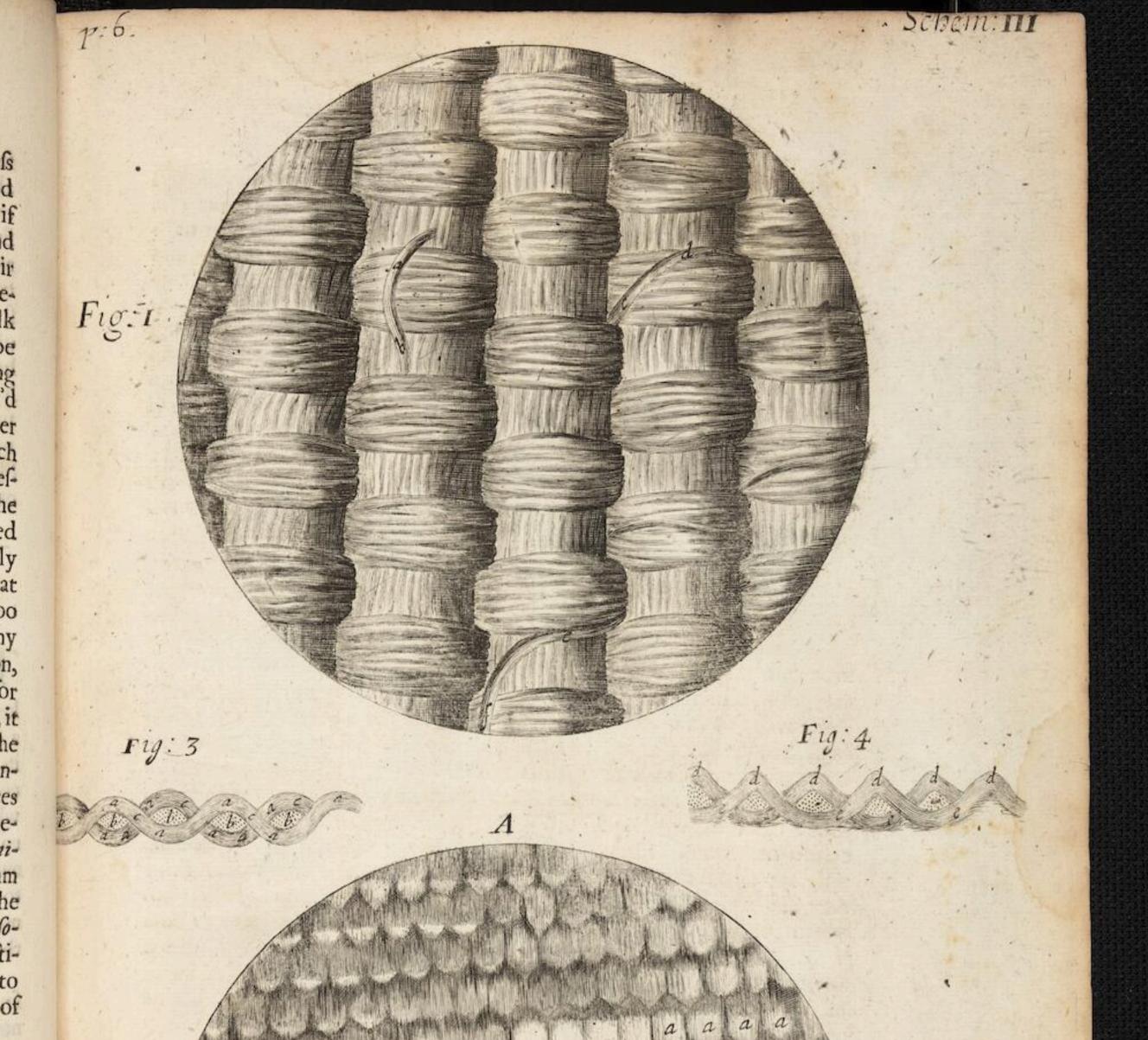
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Observ. IV. Of fine waled Silk, or Taffety.

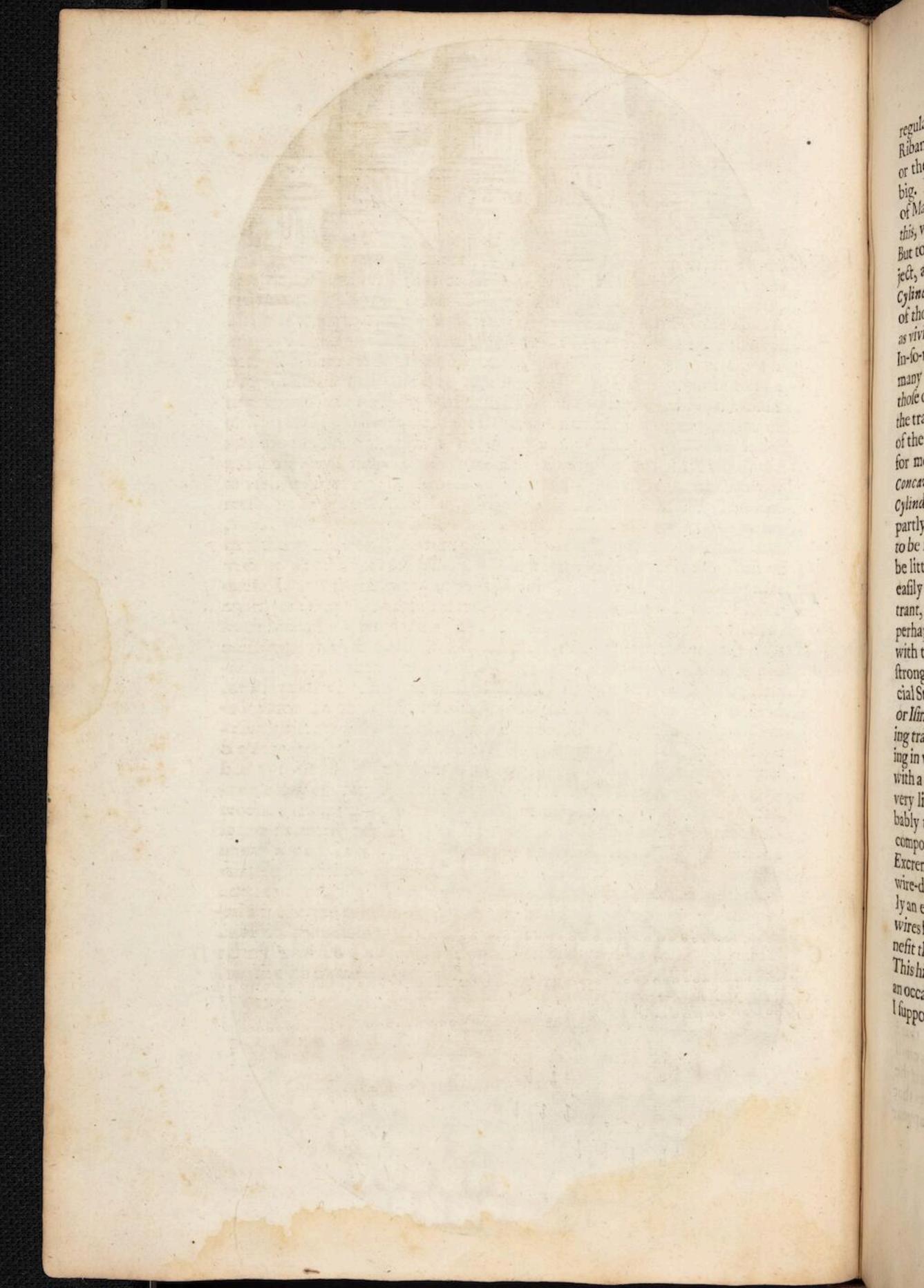
Schem. 3. Fig. 1.

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This is the appearance of a piece of very fine Taffety-riband in the bigger magnifying Glafs, which you fee exhibits it like a very convenient fubftance to make Bed-matts, or Door-matts of, or to ferve for Beehives, Corn-fcuttles, Chairs, or Corn-tubs, it being not unlike that kind of work, wherewith in many parts in *England*, they make fuch Utenfils of Straw, a little wreathed, and bound together with thongs of Brambles. For in this Contexture, each little filament, fiber, or clew of the Silk-worm, feem'd about the bignefs of an ordinary Straw, as appears by the little irregular



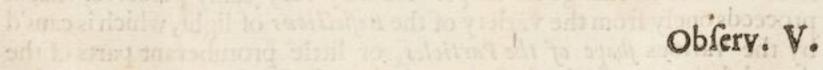
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regular pieces, a b, c d, and ef; The Warp, or the thread that ran croffing the Riband, appear'd like a fingle Rope of an Inch Diameter; but the Woof, or the thread that ran the length of the Riband, appear'd not half fo big. Each Inch of fix-peny-broad Riband appearing no lefs then a piece of Matting Inch and half thick, and twelve foot fquare; a few yards of this, would be enough to floor the long Gallery of the Loure at Paris. But to return to our piece of Riband : It affords us a not unpleafant object, appearing like a bundle, or wreath, of very clear and transparent Cylinders, if the Silk be white, and curioufly ting'd; if it be colour'd, each of those small horney Cylinders affording in some place or other of them, as vivid a reflection, as if it had been fent from a Cylinder of Glafs or Horn. In-fo-much, that the reflections of Red, appear'd as if coming from fo many Granates, or Rubies. The loveliness of the colours of Silks above those of hairy Stuffs, or Linnen, confisting as I else-where intimate, chiefly in the transparency, and vivid reflections from the Concave, or inner furface of the transparent Cylinder, as are also the colours of Precious Stones; for most of the reflections from each of these Cylinders, come from the Concave furface of the air, which is as 'twere the foil that incompasses the Cylinder. The colours with which each of these Cylinders are ting'd, feem partly to be superficial, and sticking to the out-fides of them; and partly, to be imbib'd, or funck into the fubstance of them : for Silk, feeming to be little elfe then a dried thread of Glew, may be fuppos'd to be very eafily relaxt, and foftened, by being fteeped in warm, nay in cold, if penetrant, juyces or liquors. And thereby those tinctures, though they tinge' perhaps but a fmall part of the fubftance, yet being fo highly impregnated with the colour, as to be almost black with it, may leave an impression ftrong enough to exhibite the defir'd colour. A pretty kinde of artificial Stuff I have feen, looking almost like transparent Parchment, Horn, or Ifing-glafs, and perhaps fome fuch thing it may be made of, which being transparent, and of a glutinous nature, and eafily mollified by keeping in water, as I found upon trial, had imbib'd, and did remain ting'd with a great variety of very vivid colours, and to the naked eye, it look'd very like the fubstance of the Silk. And I have often thought, that probably there might be a way found out, to make an artificial glutinous composition, much refembling, if not full as good, nay better, then that Excrement, or whatever other fubftance it be out of which, the Silk-worm wire-draws his clew. If fuch a composition were found, it were certainly an easie matter to find very quick ways of drawing it out into small wires for ufe. I need not mention the ufe of fuch an Invention, nor the benefit that is likely to accrue to the finder, they being fufficiently obvious. This hint therefore, may, I hope, give fome Ingenious inquifitive Perfon an occasion of making fome trials, which if fuccessfull, I have my aim, and I suppose he will have no occasion to be displeas'd.

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Observ. V. Of watered Silks, or Stuffs.

Schem. 3. Fig. 2.

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Here are but few Artificial things that are worth observing with a Microscope ; and therefore I shall speak but briefly concerning them. For the Productions of art are fuch rude mif-fhapen things, that when view'd with a Microscope, there is little elfe observable, but their deformity. The most curious Carvings appearing no better then those rude Russian Images we find mention'd in Purchas, where three notches at the end of a Stick, ftood for a face. And the most smooth and burnish'd surfaces appear most rough and unpolisht : So that my first Reason why I shall add but a few observations of them, is, their mis-shapen form; and the next, is their uselessness. For why should we trouble our selves in the examination of that form or shape (which is all we are able to reach with a Microscope) which we know was defign'd for no higher a ufe, then what we were able to view with our naked eye? Why fhould we endeavour to difcover mysteries in that which has no fuch thing in it? And like Rabbins find out Caballisms, and anigmas in the Figure, and placing of Letters, where no fuch thing lies hid : whereas in natural forms there are fome fo fmall, and fo curious, and their defign'd bufinels fo far remov'd beyond the reach of our fight, that the more we magnify the object, the more excellencies and mysteries do appear; And the more we discover the imperfections of our fenses, and the Omnipotency and Infinite perfections of the great Creatour. I shall therefore onely add one or two Observations more of artificial things, and then come to the Treaty concerning fuch matters as are the Productions of a more curious Workman. One of these, shall be that of a piece of water'd Silk, reprefented in the fecond Figure of the third Scheme, as it appear'd through the least magnifying Glass. A B. fignifying the long way of the Stuff, and C D the broad way. This Stuff, if the right fide of it be looked upon, appears to the naked eye, all over fo waved, undulated, or grain'd, with a curious, though irregular variety of brighter and darker parts, that it adds no small gracefulness to the Gloss of it. It is fo known a propriety, that it needs but little explication, but it is obfervable, which perhaps every one has not confidered, that those parts which appear the darker part of the wave, in one polition to the light, in another appears the lighter, and the contrary; and by this means the undulations become transient, and in a continual change, according as the pofition of the parts in respect of the incident beams of light is varied. The reafon of which odd phanomena, to one that has but diligently examin'd it even with his naked eye, will be obvious enough. But he that observes it with a Microscope, may more eafily perceive what this Protens is, and how it comes to change its shape. He may very easily perceive, that it proceeds onely from the variety of the Reflections of light, which is caus'd by the various shape of the Particles, or little protuberant parts of the thread that compose the furface; and that those parts of the waves that appear

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appear the brighter throw towards the eye a multitude of fmall reflections of light, whereas the darker fcarce afford any. The reafon of which reflection, the Microscope plainly difcovers, as appears by the Figure. In which you may perceive, that the brighter parts of the furface confift of an abundance of large and ftrong reflections, denoted by a, a, a, a, a, &c. for the furfaces of those threads that run the long way, are by the Mechanical process of watering, creas'd or angled in another kind of posture then they were by the weaving: for by the weaving they are onely bent round the warping threads; but by the watering, they are bent with an angle, or elbow, that is in ftead of lying, or being bent round the threads, as in the third Figure, a, a, a, a, a, are about b,b,b (b,b,b reprefenting the ends, as 'twere, of the cross threads, they are bent about) they are creas'd on the top of those threads, with an angle, as in the fourth Figure, and that with all imaginable variety; fo that, whereas before they reflected the light onely from one point of the round furface, as about c, c, c, they now when water'd, reflect the beams from more then half the whole furface, as de, de, de, and in other postures they return no reflections at all from those furfaces. Hence in one posture they compose the brighter parts of the waves, in another the darker. And these reflections are also varied, according as the particular parts are varioufly bent. The reafon of which creafing we shall next examine; and here we must fetch our information from the Mechanism or manner of proceeding in this operation ; which, as I have been inform'd, is no other then this.

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They double all the Stuff that is to be water'd, that is, they creafe it just through the middle of it, the whole length of the piece, leaving the right fide of the Stuff inward, and placing the two edges, or filvages just upon one another, and, as near as they can, place the wale fo in the doubling of it, that the wale of the one fide may lie very near parallel, or even with the wale of the other; for the nearer that posture they lie, the greater will the watering appear; and the more obliquely, or across to each other they lie, the smaller are the waves. Their way for folding it for a great wale is thus : they take a Pin, and begin at one fide of the piece in any wale, and fo moving it towards the other fide, thereby direct their hands to the oppolite ends of the wale, and then, as near as they can, place the two oppolite ends of the fame wale together, and fo double, or fold the whole piece, repeating this enquiry with a Pin at every yard or two's diftance through the whole length; then they fprinkle it with water, and fold it the longways, placing between every fold a piece of Paftboard, by which means all the wrong fide of the water'd Stuff becomes flat, and with little wales, and the wales on the other fide become the more protuberant; whence the creafings or angular bendings of the wales become the more perfpicuous. Having folded it in this manner, they place it with an interjacent Paftboard into an hot Prefs, where it is kept very violently preft, till it be dry and ftiff; by which means, the wales of either contiguous fides leave their own impressions upon each other, as is very manifeft by the fecond Figure, where 'tis obvious enough, that the wale of the piece A B C D runs parallel between the pricked lines ef, ef, ef, and as manifeft

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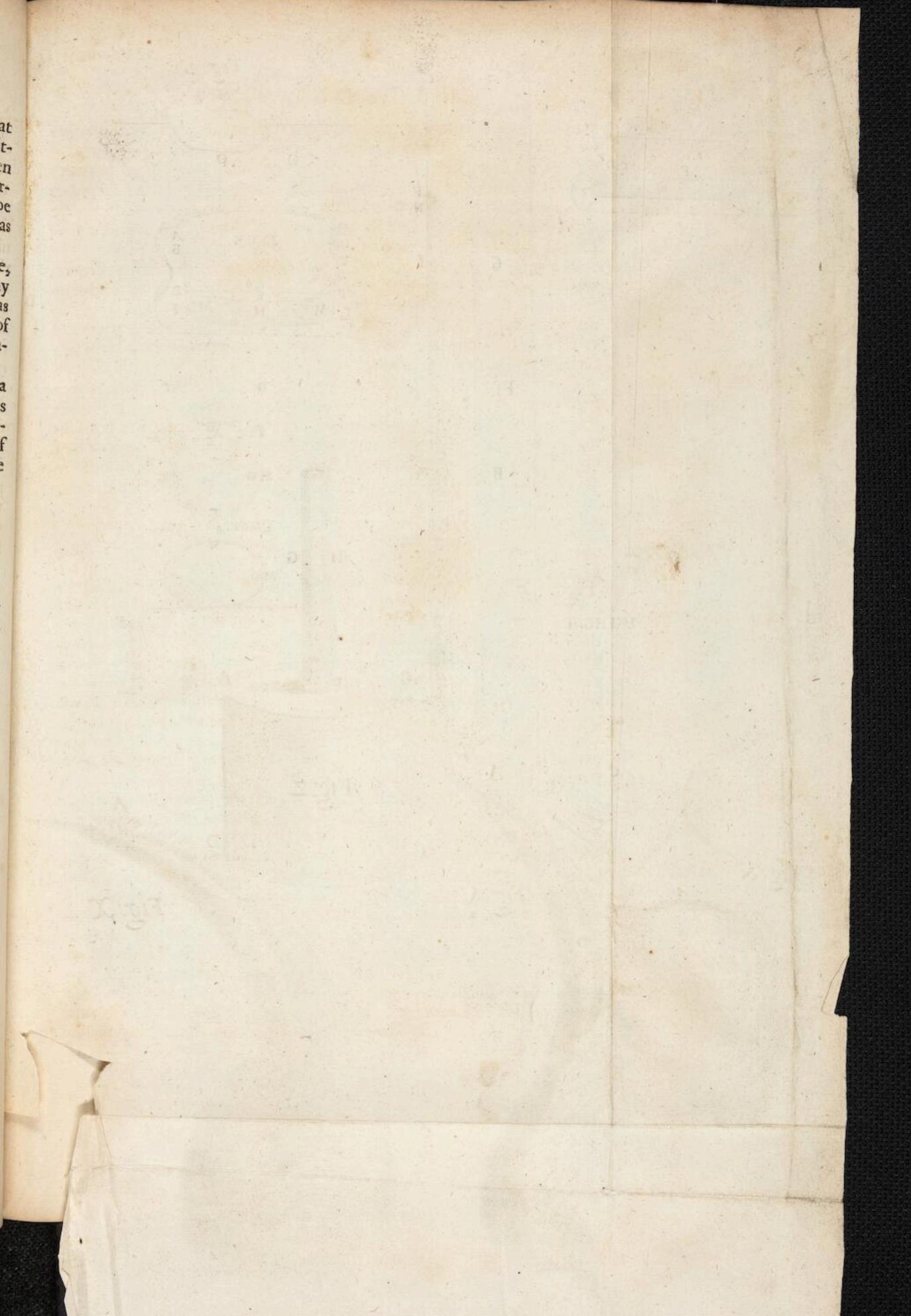
manifest to difcern the impressions upon these wales, left by those that were preft upon them, which lying not exactly parallel with them, but a little athwart them, as is denoted by the lines of, ooo, gh. gh.gh, between which the other wales did lie parallel; they are fo varioufly, and irregularly creas'd that being put into that fhape when wet, and kept fo till they be drie, they fo fet each others threads, that the Moldings remain almost as long as the Stuff lafts.

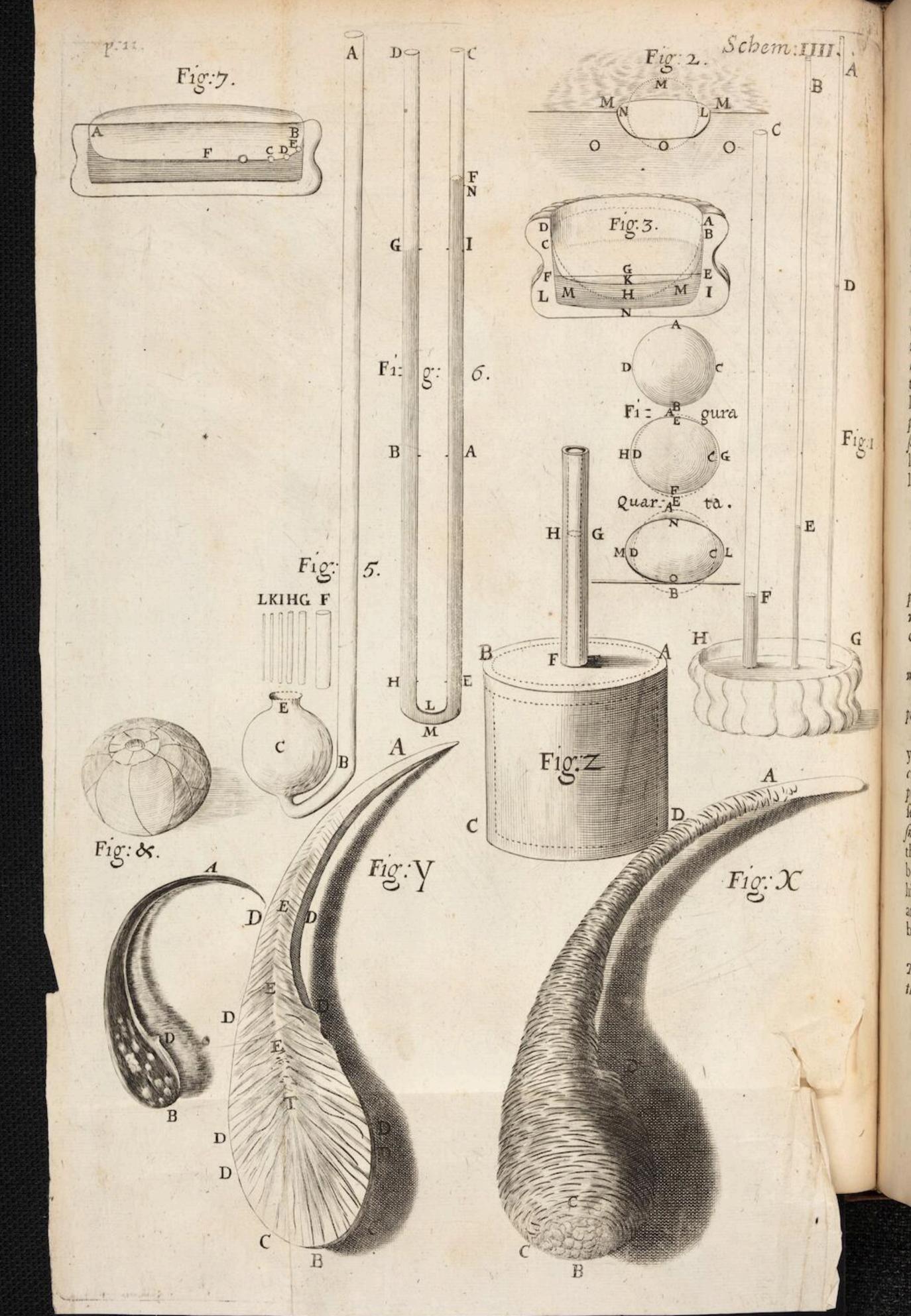
Hence it may appear to any one that attentively confiders the Figure, why the parts of the wale a, a, a, a, a, a, a, fhould appear bright; and why the parts b, b, b, b, b, b, fhould appear fhadowed, or dark; why fome, as d,d,d,d,d,d, fhould appear partly light, and partly dark : the varieties of which reflections and fhadows are the only caufe of the appearance of watering in Silks, or any other kind of Stuffs.

From the variety of reflection, may also be deduc'd the cause why a fmall breez or gale of wind ruffling the furface of a fmooth water, makes it appear black; as also, on the other fide, why the smoothing or burnishing the furface of whitened Silver makes it look black ; and multitudes of other phænomena might hereby be folv'd, which are too many to be here infifted on.

Observ. VI. Of small Glass Canes.

Sebem. 4. Hat I might be fatisfi'd, whether it were not poffible to make an Artificial pore as small as any Natural I had yet found, I made feveral attemps with small glass pipes, melted in the flame of a Lamp, and then very fuddenly drawn out into a great length. And, by that means, without much difficulty, I was able to draw fome almost as small as a Cobweb, which yet, with the Microscope, I could plainly perceive to be perforated, both by looking on the ends of it, and by looking on it against the light; which was much the easter way to determine whether it were folid or perforated; for, taking a small pipe of glass, and closing one end of it, then filling it half full of water, and holding it against the light, I could, by this means, very eafily find what was the differing afpect of a folid and a perforated piece of glass; and so eafily diftinguish, without feeing either end, whether any Cylinder of glass I look'd on, were a folid flick, or a hollow cane. And by this means, I could also prefently judge of any small filament of glass, whether it were hollow or not, which would have been exceeding tedious to examine by looking on the end. And many fuch like ways I was fain to make use of, in the examining of divers other particulars related in this Book, which would have been no eafie task to have determined meerly by the more common way of looking on, or viewing the Object. For, if we confider first, the very faint light wherewith the object is enlightened, whence many particles appear opacous, which when more enlightned, appear very transparent, fo that I was fain to determine its transparency by one glass, and its texture by another Next, the unmanageableness of most Objects, by reason of





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of their smalness, 3. The difficulty of finding the defired point, and of placing it fo, as to reflect the light conveniently for the Inquiry, Laftly, ones being able to view it but with one eye at once, they will appear no small obstructions, nor are they easily removed without many contrivances. But to proceed, I could not find that water, or fome deeply ting'd liquors would in fmall ones rife fo high as one would expect; and the bigheft I have found it yet rife in any of the pipes I have try'd, was to 21 inches above the level of the water in the veffel: for though I found that in the small pipes it would nimbly enter at first, and run about 6 or 7 inches upwards; yet I found it then to move upwards fo flow, that I have not yet had the patience to observe it above that height of 21 inches (and that was in a pretty large Pipe, in comparison of those I formerly mentioned; for I could observe the progress of a very deep ting'd liquor in it with my naked eye, without much trouble; whereas many of the other pipes were fo very small, that unless in a convenient posture to the light, I could not perceive them :) But 'tis very probable, that a greater patience and affiduity may discover the liquors to rife, at least to remain sufpended, at heights that I should be loath now even to ghess at, if at least there be any proportion kept between the height of the afcending liquor, and the bigness of the holes of the pipes.

An Attempt for the Explication of this Experiment.

My Conjecture, That the unequal height of the surfaces of the water, Schem. 4. proceeded from the greater pressure made upon the water by the Air Fig. 1. without the Pipes A B C, then by that within them; I shall endeavour to confirm from the truth of the two following Propositions:

The first of which is, That an unequal pressure of the incumbent Air, will cause an unequal height in the water's Surfaces.

And the fecond is, That in this experiment there is such an unequal pressure.

That the first is true, the following Experiment will evince. For if you take any Veflel fo contrived, as that you can at pleafure either in-

crease or diminish the pressure of the Air upon this or that part of the Superficies of the mater, the equality of the height of those parts will prefently be lost; and that part of the Superficies that fustains the greater preffure, will be inferior to that which undergoes the lefs. A fit Veffel for this purpose, will be an inverted Glass Syphon, such an one as is deferibed in the Sixth Figure. For if into it you put Water enough to fill it as high as AB, and gently blow in at D, you shall depress the Superficies B, and thereby raise the opposite Superficies A to a considerable height, and by gently *jucking* you may produce clean contrary effects.

Next, That there is fuch an unequal pressure, I shall prove from this, That there is a much greater incongruity of Air to Glass, and some other Bodies, then there is of Water to the fame. D₂ By

By Congruity, I mean a property of a fluid Body, whereby any part of it is readily united with any other part, either of it felf, or of any other Similar, fluid, or folid body: And by Incongruity a property of a fluid, by which it is hindred from uniting with any diffimilar, fluid, or folid Body.

This last property, any one that hath been observingly conversant about fluid Bodies, cannot be ignorant of. For (not now to mention feveral Chymical Spirits and Oyls, which will very hardly, if at all, be brought to mix with one another; infomuch that there may be found fome 8 or 9, or more, feveral diftinct Liquors, which fivimming one upon another, will not prefently mix) we need feek no further for Examples of this kind in fluids, then to observe the drops of rain falling through the air, and the bubbles of air which are by any means conveyed under the furface of the mater; or a drop of common sallet Oyl fwimming upon water. In all which, and many more examples of this kind that might be enumerated, the incongruity of two fluids is eafily difcernable. And as for the Congruity or Incongruity of Liquids, with feveral kinds of firm Bodies, they have long fince been taken notice of, and called by the Names of Drinefs and Moifture (though these two names are not comprehenfive enough, being commonly used to fignifie only the adhering or not adhering of mater to fome other folid Bodies) of this kind we may obferve that water will more readily wet some woods then others ; and that water, let fall upon a Feather, the whiter fide of a Colwort, and fome other leaves, or upon almost any dusty, unctuous, or resinous superficies, will not at all adhere to them, but eafily tumble off from them, like a folid Bowl; whereas, if dropt upon Linnen, Paper, Clay, green Wood, &c. it will not be taken off, without leaving fome part of it behind adhering to them. So Quick-filver, which will very hardly be brought to flick to any vegetable body, will readily adhere to, and mingle with, feveral clean metalline bodies.

And that we may the better finde what the caufe of Congruity and Incongruity in bodies is, it will be requifite to confider, First, what is the cause of fluidness; And this, I conceive, to be nothing else but a certain pulfe or shake of heat; for Heat being nothing elfe but a very brisk and vehement agitation of the parts of a body (as I have ellwhere made probabable) the parts of a body are thereby made to loofe from one another, that they eafily move any way, and become fluid. That I may explain this a little by a gross Similitude, let us suppose a dish of fand set upon fome body that is very much agitated, and shaken with some quick and ftrong vibrating motion, as on a Milftone turn'd round upon the under ftone very violently whilft it is empty; or on a very ftiff Drum-head, which is vehemently or very nimbly beaten with the Drumsticks. By this means, the fand in the difh, which before lay like a dull and unactive body, becomes a perfect fluid; and ye can no fooner make a hole in it with your finger, but it is immediately filled up again, and the upper furface of it levell'd. Nor can you bury a light body, as a piece of Cork under it, but it prefently emerges or frims as 'twere on the top; nor can you lay a heavier on the top of it, as a piece of Lead, but it is immediately buried

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in Sand, and (as 'twere) finks to the bottom. Nor can you make a hole in the fide of the Difh, but the fand shall run out of it to a level, not an obvious property of a fluid body, as fuch, but this dos imitate; and all this meerly caufed by the vehement agitation of the conteining veffel; for by this means, each fand becomes to have a vibrative or dancing motion, so as no other heavier body can rest on it, unless sufteind by some other on either fide : Nor will it fuffer any Body to be beneath it, unlefs it be a heavier then it felf. Another Instance of the strange loofening nature of a violent jarring Motion, or a ftrong and nimble vibrative one, we may have from a piece of iron grated on very ftrongly with a file : for if into that a pin be fcrew'd fo firm and hard, that though it has a convenient head to it, yet it can by no means be unferen'd by the fingers; if, I fay, you attempt to unferew this whilft grated on by the file, it will be found to undoe and turn very eafily. The first of these Examples manifests, how a body actually divided into small parts, becomes a fluid. And the latter manifests by what means the agitation of heat so eafily loofens and unties the parts of folid and firm bodies. Nor need we fuppose heat to be any thing else, besides such a motion ; for supposing we could Mechanically produce fuch a one quick and ftrong enough, we need not fpend fuel to melt a body. Now, that I do not fpeak this altogether groundlefs, I must refer the Reader to the Observations I have made upon the thining sparks of Steel, for there he shall find that the fame effects are produced upon small chips or parcels of Steel by the flame, and by a quick and violent motion; and if the body of steel may be thus melted (as I there fhew it may) I think we have little reafon to doubt that almost any other may not alfo. Every Smith can inform one how quickly both his File and the Iron grows hot with filing, and if you rub almost any two hard bodies together, they will do the fame : And we know, that a fufficient degree of heat caufes fluidity, in fome bodies much fooner, and in others later; that is, the parts of the body of some are so lasse from one another, and fo unapt to cohere, and fo minute and little, that a very small degree of agitation keeps them always in the state of fluidity. Of this kind, I suppose, the Æther, that is the medium or fluid body, in which all other bodies do as it were fwim and move; and particularly, the Air, which feems nothing elfe but a kind of tindure or folution of terrestrial and aqueous particles diffelv'd into it, and agitated by it, just as the tine fure of Cocheneel is nothing but some finer diffoluble parts of that Concrete lick'd up or diffelv'd by the fluid water. And from this Notion of it, we may eafily give a more Intelligible reason how the Air becomes fo capable of Rarefaction and Condensation. For, as in tinctures, one grain of fome ftrongly tinging substance may fensibly colour some hundred thoufand grains of appropriated Liquors, so as every drop of it has its proportionate share, and be fensibly ting'd, as I have try'd both with Logwood and cocheneel : And as fome few grains of salt is able to infect as great a quantity, as may be found by pracipitations, though not to eatily by the fight or afte; fo the Air, which feems to be but as 'twere a tinefure or faline substance, disolv'd and agitated by the fluid and agil Æther, may difperfe

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perfe and expand it self into a vast space, if it have room enough, and infect, as it were, every part of that space. But, as on the other fide, if there be but some few grains of the liquor, it may extract all the colour of the tinging fubstance, and may diffolve all the Salt, and thereby become much more impregnated with those substances, fo may all the air that fufficed in a rarify'd state to fill some hundred thousand spaces of Æther, be compris'd in only one, but in a position proportionable dense. And though we have not yet found out fuch strainers for Tinctures and Salts as we have for the Air, being yet unable to separate them from their diffolving liquors by any kind of filtre, without pracipitation, as we are able to feparate the Air from the Æther by Glass, and feveral other bodies. And though we are yet unable and ignorant of the ways of pracipitating Air out of the Æther as we can Tinctures, and Salts out of feveral diffolvents; yet neither of these feeming impossible from the nature of the things, nor fo improbable but that fome happy future industry may find out ways to effect them; nay, further, fince we find that Nature does really perform (though by what means we are not certain) both these actions, namely, by pracipitating the Air in Rain and Dews, and by supplying the Streams and Rivers of the World with fresh water, strain'd through fecret fubterraneous Caverns: And fince, that in very many other proprieties they do so exactly feem of the same nature; till further observations or tryals do inform us of the contrary, we may fafely enough conclude them of the fame kind. For it feldom happens that any two natures have fo many properties coincident or the fame, as I have observ'd Solutions and Air to have, and to be different in the reft. And therefore I think it neither impossible, irrational, nay nor difficult to be able to predict what is likely to happen in other particulars also, befides those which Observation or Experiment have declared thus or thus; especially, if the circumftances that do often very much conduce to the variation of the effects be duly weigh'd and confider'd. And indeed, were there not a probability of this, our inquiries would be endlefs, our tryals vain, and our greateft inventions would be nothing but the meer products of chance, and not of Reason; and, like Mariners in an Ocean, destitute both of a Compass and the fight of the Celeftial guids, we might indeed, by chance, Steer directly towards our defired Port, but 'tis a thousand to one but we miss our aim. But to proceed, we may hence also give a plain reason, how the Air comes to be darkned by clouds, &c. which are nothing but a kind of precipitation, and how those precipitations fall down in showrs. Hence also could I very eafily, and I think truly, deduce the caufe of the curious fix angular figures of Snow, and the appearances of Haloes, &.c. and the fudden thickning of the Sky with Clouds, and the vanishing and disappearing of those Clouds again; for all these things may be very easily imitated in a glass of liquor, with fome flight Chymical preparations as I have often try'd, and may fomewhere elfe more largely relate, but have not now time to fet them down. But to proceed, there are other bodies that confift of particles more Gross, and of a more apt figure for cohelion, and this requires a somewhat greater agitation ; such, I suppose 9. fermented vinous Spirits

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Spirits, feveral Chymical Oils, which are much of kin to those Spirits, &c. Others yet require a greater, as water, and so others much greater, for almost infinite degrees: For, I suppose there are very few bodies in the world that may not be made aliquatenus fluid, by some or other degree of agitation or heat.

Having therefore in fhort fet down my Notion of a Fluid body, I come in the next place to confider what Congruity is; and this, as I faid before, being a Relative property of a fluid, whereby it may be faid to be like or unlike to this or that other body, whereby it does or does not mix with this or that body. We will again have recourse to our former Experiment, though but a rude one; and here if we mix in the difh feveral kinds of fands, fome of bigger, others of lefs and finer bulks, we shall find that by the agitation the fine fand will eject and throw out of it felf all those bigger bulks of fmall stones and the like, and those will be gathered together all into one place; and if there be other bodies in it of other natures, those also will be separated into a place by themselves, and united or tumbled up together. And though this do not come up to the highest property of Congruity, which is a Cohafion of the parts of the fluid together, or a kind of attraction and tenacity, yet this does as 'twere shadow it out, and somewhat refemble it; for just after the same manner, I suppose the pulse of heat to agitate the small parcels of matter, and those that are of a like bigness, and figure, and matter, will hold, or dance together, and those which are of a differing kind will be thrust or shou'd out from between them; for particles that are all similar, will, like fo many equal musical strings equally stretcht, vibrate together in a kind of Harmony or unifon; whereas others that are diffimilar, upon what account foever, unless the disproportion be otherwise counter-ballanc'd, will, like so many ftrings out of tune to those unifons, though they have the fame agitating pulse, yet make quite differing kinds of vibrations and repercussions, fo that though they may be both mov'd, yet are their vibrations fo different, and fo untun'd, as 'twere to each other, that they cross and jar against each other, and confequently, cannot agree together, but fly back from each other to their fimilar particles. Now, to give you an inftance how the disproportion of some bodies in one respect, may be counter-ballanc'd by a contrary difproportion of the fame body in another refpect, whence we find that the fubtil vinous spirit is congruous, or does readily mix with water, which in many properties is of a very differing nature, we may confider that a unifon may be made either by two ftrings of the fame bignefs; length, and tension, or by two strings of the same bigness, but of differing length, and a contrary differing tension; or 3ly. by two strings of unequal length and bigness, and of a differing tension, or of equal length, and differing bigness and tension, and leveral other such varieties. To which three properties in strings, will correspond three proprieties also in fand, or the particles of bodies, their Matter or Substance, their Figure or Shape, and their Body or Bulk. And from the varieties of these three, may arise infinite varieties in fluid bodies, though all agitated by the same pulse or vibrative motion. And there may be as many ways of making Harmonies and

and Difcords with thefe, as there may be with musical strings. Having therefore feen what is the caufe of Congruity or Incongruity, those relative properties of fluids, we may, from what has been faid, very eafily collect, what is the reason of those Relative proprieties also between fluid bodies and folid; for fince all bodies confift of particles of fuch a substance, Figure, and Bulk; but in some they are united together more firmly then to be loofened from each other by every vibrative motion (though I imagine that there is no body in the world, but that fome degree of agitation may, as I hinted before, agitate and loofen the particles fo as to make them fluid) those cohering particles may vibrate in the fame manner almost as those that are loofe and become unifons or discords, as I may fo speak, to them. Now that the parts of all bodies, though never fo folid, do yet vibrate, I think we need go no forther for proof, then that all bodies have fome degrees of heat in them, and that there has not been yet found any thing perfectly cold: Nor can I believe indeed that there is any fuch thing in Nature, as a body whole particles are at rest, or lazy and unactive in the great Theatre of the World, it being quite contrary to the grand Oeconomy of the Universe. We see therefore what is the reafon of the sympathy or uniting of some bodies together, and of the antipathy or flight of others from each other : For Congruity feems nothing elfe but a Sympathy, and Incongruity an Antipathy of bodies; hence fimilar bodies once united will not eafily part, and diffimilar bodies once difjoyn'd will not eafily unite again; from hence may be very eafily deduc'd the reason of the suspension of water and Quick-filver above their usual station, as I fhall more at large anon fhew.

These properties therefore (alwayes the concomitants of fluid bodies) produce these following visible Effects:

First, They unite the parts of a fluid to its similar Solid, or keep them separate from its dissimilar. Hence Quick-filver will (as we noted before) Stick to Gold, Silver, Tin, Lead, &c. and unite with them : but roul off from Wood, Stone, Glass, &c. if never fo little feituated out of its horizontal lewel; and water that will wet falt and diffolve it, will flip off from Tallow, or the like, without at all adhering; as it may likewife be observed to do upon a dufty superficies. And next they cause the parts of homogeneal fluid bodies readily to adhere together and mix, and of heterogeneal, to be exceeding averse thereunto. Hence we find, that two small drops of water, on any superficies they can roul on, will, if they chance to touch each other, readily unite and mix into one 3d drop: The like may be obferved with two small Bowls of Quick-filver upon a Table or Glafs, provided their furfaces be not dufty; and with two drops of Oyl upon fair water, O.c. And further, mater put unto wine, falt water, vinegar, spirit of wine, or the like, does immediately (efpecially if they be shaken together) disperse it felf all over them. Hence, on the contrary, we also find, that Oyl of Tartar poured upon Quick-filver, and Spirit of Wine on that Oyl, and Oyl of Turpentine on that Spirit, and Air upon that Oyl, though they be ftopt closely up into a Bottle, and shaken never fo much, they will by no means long fuffer any of their bigger parts to be united or included DEAR

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cluded within any of the other Liquors(by which recited Liquors, may be plainly enough reprefented the four *Peripatetical Elements*, and the more fubtil *Æther* above all.) From this property tis, that a drop of *water* does not mingle with, or vanifh into *Air*, but is *driven* (by that Fluid equally protruding it on every fide) and forc't into as little a fpace as it can poffibly be contained in, namely, into a *Round Globule*. So likewife a'little *Air* blown under the *mater*, is *united* or thruft into a *Bubble* by the ambient water. And a parcel of *Quick-filver* enclosed with *Air*, *Water*, or almoft any other *Liquor*, is formed into a round Ball.

Now the caufe why all thefe included Fluids, newly mentioned, or as many others as are wholly included within a heterogeneous fluid, are not exactly of a spherical Figure (feeing that if caufed by thefe Principles only, it could be of no other) mult proceed from fome other kind of prefure against the two opposite flatted fides. This adventitious or accidental prefure may proceed from divers caufes, and accordingly mult diversifie the Figure of the included heterogeneous fluid : For feeing that a body may be included either with a fluid only, or only with a folid, or partly with a fluid, and partly with a folid, or partly with one fluid, and partly with another; there will be found a very great variety of the terminating furfaces, much differing from a spherical, according to the various refiltance or preflure that belongs to each of thefe encompassing bodies.

Which Properties may in general be deduced from two heads, viz. Motion, and Rest. For, either this Globular Figure is altered by a natural Motion, fuch as is Gravity; or a violent, fuch as is any accidental motion of the fluids, as we see in the wind ruffling up the water, and the purlings of Streams, and foaming of Catarracts, and the like. Or thirdly, By the Reft, Firmness and Stability of the ambient solid. For if the including solid be of an angular or any other irregular Form, the included fluid will be near of the like, as a Pint-Pot full of water, or a Bladder full of Air. And next, if the including or included fluid have a greater gravity one than another, then will the globular Form be depreft into an Elliptico-Spherical : As if, for example, we suppose the Circle A B C D, in the fourth Figure, to represent a drop of water, Quick-filver, or the like, included with the Air or the like, which supposing there were no gravity at all in either of the fluids, or that the contained and containing were of the fame weight, would be equally comprest into an exactly spherical body (the ambient fluid forcing equally against every fide of it.) But supposing either a greater gravity in the included, by reason whereof the parts of it being prest from A towards B, and thereby the whole put into motion, and that motion being hindred by the refistance of the subjacent parts of the ambient, the globular Figure A D B C will be deprest into the Ellipticospherical, EGFH. For the fide A is detruded to E by the Gravity, and B to F by the resistance of the subjacent medium : and therefore C mult necessarily be thrust to G; and D to H. Or else, supposing a greater gravity in the ambient, by whole more then ordinary preffure against the under tide of the included globule; B will be forced to F, and by its reliftance of ONC the

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the motion upwards, the fide A will be deprest to E, and therefore C being thrust to G and D to H; the globular Figure by this means also will be made an Elliptico-spherical. Next if a fluid be included partly with one, and partly with another fluid, it will be found to be shaped diversly, according to the proportion of the gravity and incongruity of the 3 fluids one to another : As in the fecond Figure, let the upper MMM be Air, the middle L MNO be common Oyl, the lower 000 be Water, the Oyl will be form'd, not into a spherical Figure, such as is represented by the pricked Line, but into fuch a Figure as LMNO, whole fide LMN will be of a flatter Elliptical Figure, by reason of the great disproportion between the Gravity of Oyl and Air, and the fide L O M of a rounder, because of the smaller difference between the weight of Oyl and Water. Lastly, The globular Figure will be changed, if the ambient be partly fluid and partly folid. And here the termination of the incompassed fluid towards the incompaffing is shap'd according to the proportion of the congruity or incongruity of the fluids to the folids, and of the gravity and incongruity of the fluids one to another. As suppose the subjacent medium that hinders an included fluids defcent, be a folid, as let K I, in the fourth Figure, represent the smooth superficies of a Table ; E G F H, a parcel of running Mercury; the fide G F H will be more flatted, according to the proportion of the incongruity of the Mercury and Air to the Wood, and of the gravity of Mercury and Air one to another ; The fide G E H will likewife be a little more deprest by reason the subjacent parts are now at reft, which were before in motion.

Or further in the third Figure, let A I L D represent an including folid medium of a cylindrical shape (as suppose a small Glass far) Let F G E M M reprefent a contain'd fluid, as water; this towards the bottom and fides, is figured according to the concavity of the Glass : But its upper Surface, (which by reafon of its gravity, (not confidering at all the Air above it, and so neither the congruity or incongruity of either of them to the Glass) should be terminated by part of a sphere whose diameter should be the fame with that of the earth, which to our fense would appear a straight Line, as F G E, Or which by reason of its having a greater congruity to Glass than Air has, (not confidering its Gravity) would be thrust into a concave Sphere, as C H B, whose diameter would be the fame with that of the concavity of the Veffel :) Its upper Surface, I fay, by reafon of its having a greater gravity then the Air, and having likewife a greater congruity to Glass then the Air has, is terminated, by a concave Elliptico-spherical Figure, as C K B. For by its congruity it eafily conforms it felf, and adheres to the Glafs, and conftitutes as it were one containing body with it, and therefore fhould thrust the contained Air on that fide it touches it, into a spherical Figure, as B H C, but the motion of Gravity depreffing a little the Corners B and C, reduces it into the aforefaid Figure C K B. Now that it is the greater congruity of one of the two contignous fluids, then of the other, to the containing folid, that caufes the separating surfaces to be thus or thus figured : And that it is not because this or that figurated surface is more proper, natural, or peculiar to one

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one of these fluid bodies, then to the other, will appear from this; that the fame fluids will by being put into differing folids, change their furfaces. For the fame water, which in a Glafs or wooden Veffel will have a concave furface upwards, and will rife higher in a finaller then a greater Pipe, the fame water, I fay, in the fame Pipes greafed over or oyled, will produce quite contrary effects; for it will have a protuber ant and convex furface upwards, and will not rife fo high in fmall, as in bigger Pipes . Nay, in the very fame folid Veffel, you may make the very fame two contiguous Liquids to alter their Surfaces; for taking a finall Wine-glass, or fuch like Veffel, and pouring water gently into it, you shall perceive the furface of the water all the way concave, till it rife even with the top, when you shall find it (if you gently and carefully pour in more) to grow very protuberant and convex; the reason of which is plain, for that the folid fides of the containing body are no longer extended, to which the water does more readily adhere then the air; but it is henceforth to be included with air, which would reduce it into a hemisphere, but by reason of its gravity, it is flatted into an Oval. Quicksilver allo which to Glafs is more incongruous then Air (and thereby being put into a Glass-pipe, will not adhere to it, but by the more congruous air will be forced to have a very protuberant furface, and to rife higher in a greater then a leffer Pipe) this Quicksilver to clean Metal, especially to Gold, Silver, Tin. Lead, &c. Iron excepted, is more congruous then Air, and will not only frick to it, but have a concave Surface like water, and rife higher in a lefs, then in a greater Pipe.

In all these Examples it is evident, that there is an extraordinary and adventitions force, by which the globular Figure of the contained heterogeneous fluid is altered; neither can it be imagined, how it fhould otherwife be of any other Figure then Globular : For being by the heterogeneons fluid equally protruded every way, what foever part is protuber ant, will be thereby deprest. From this cause it is, that in its effects it does very much refemble a round spring (fuch as a Hoop.) For as in a round spring there is required an additional pressure against two opposite lides, to reduce it into an Oval Form, or to force it in between the fides of a Hole, whole Diameter is lefs then that of the spring, there must be a confiderable force or protrusion against the concave or inner fide of the spring ; So to alter this spherical constitution of an included fluid body, there is required more preflure against opposite fides to reduce it into an Oval; and, to press it into an Hole less in Diameter then it felf, it requires a greater protrusion against all the other fides. What degrees of force are requilite to reduce them into longer and longer Ovals, or to prefs them into lefs and lefs holes, I have not yet experimentally calculated ; but thus much by experiment I find in general, that there is alwayes required a greater preffure to close them into longer Ovals, or protude them into smaller holes. The necessity and reason of this, were it requisite, I could easily explain: but being not fo neceffary, and requiring more room and time then I have for it at prefent, I shall here omit it; and proceed to shew, that this may be prefently found true, if Experiment be made with a WORL E 2 round

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round spring (the way of making which trials is obvious enough.) And with the fluid bodies of Mercury, Air, Oc, the way of trying which, will be fomewhat more difficult; and therefore I fhall in brief defcribe it. He therefore that would try with Air, must first be provided of a Glass-pipe, made of the shape of that in the fifth Figure, whereof the side A B, represents a straight Tube of about three soot long, C, represents another part of it, which consists of a round Bubble; so ordered, that there is left a passing or hole at the top, into which may be fastened with cement several south the source of th

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There may be added as many more, as the Experimenter fhall think fit, with holes continually decreafing by known quantities, fo far as his fenfes are able to help him; I fay, fo far, becaufe there may be made *Pipes* fo fmall that it will be impoffible to perceive the *perforation* with ones naked eye, though by the help of a *Microfcope*, it may eafily enough be perceived: Nay, I have made a *Pipe* perforated from end to end, fo fmall, that with my naked eye I could very hardly fee the body of it, infomuch that I have been able to knit it up into a knot without breaking: And more accurately examining one with my *Microfcope*, I found it not fo big as a fixteenth part of one of the fmaller hairs of my head which was of the fmaller and finer fort of hair, fo that fixteen of thefe *Pipes* bound faggot-wife together, would but have equalized one fingle hair; how fmall therefore muft its *perforation* be? It appearing to me through the *Microfcope* to be a proportionably *thick-fided Pipe*.

To proceed then, for the trial of the Experiment, the Experimenter must place the Tube A B, perpendicular, and fill the Pipe F (cemented into the hole E) with water, but leave the bubble C full of Air, and then gently pouring in water into the Pipe A B, he must observe diligently how high the water will rife in it before it protrude the bubble of Air C, through the narrow passage of F, and denote exactly the height of the Cylinder of water, then cementing in a fecond Pipe as G, and filling it with water; he may proceed as with the former, denoting likewife the height of the Cylinder of water, able to protrude the bubble C through the paffage of G, the like may he do with the next Pipe, and the next, &c. as far as he is able : then comparing the feveral heights of the Cylinders, with the feveral holes through which each Cylinder did force the air (having due regard to the Cylinders of water in the small Tubes) it will be very easie to determine, what force is requisite to press the Air into such and such a hole, or (to apply it to our present experiment) how

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how much of the preffure of the Air is taken off by its ingressinto fmaller and smaller holes. From the application of which to the entring of the Air into the bigger hole of the Veffel, and into the smaller hole of the Pipe, we shall clearly find, that there is a greater prefiure of the air upon the water in the Veffel or greater pipe, then there is upon that in the leffer pipe: For fince the preflure of the air every way is found to be equal, that is, as much as is able to prefs up and fustain a Cylinder of Quicksilver of two foot and a half high, or thereabouts; And fince of this prefiure fo many more degrees are required to force the Air into a fmaller then into a greater hole that is full of a more congruous fluid. And laftly, fince those degrees that are requisite to press it in, are thereby taken off from the Air within, and the Air within left with fo many degrees of prefiure less then the Air without ; it will follow, that the Air in the less Tube or pipe, will have less pressure against the superficies of the mater therein, then the Air in the bigger : which was the minor Proposition to be proved.

The Conclusion therefore will necessarily follow, viz. That this unequal pressure of the Air caused by its ingress into unequal holes, is a cause sufficient to produce this effect, without the help of any other concurrent; and therefore is probably the principal (if not the only) caufe of these Phanomena.

This therefore being thus explained, there will be divers Phanomena explicable thereby, as, the rifing of Liquors in a Filtre, the rifing of Spirit of Wine, Oyl, melted Tallow, O.c. in the Week of a Lamp, (though made of small Wire, Threeds of Asbestus, Strings of Glass, or the like) the rising of Liquors in a Spunge, piece of Bread, Sand, O.c. perhaps also the ascending of the Sap in Trees and Plants, through their fmall, and fome of them imperceptible pores, (of which I have faid more, on another occasion) at least the passing of it out of the earth into their roots. And indeed upon the confideration of this Principle, multitudes of other ules of it occurr'd tome, which I have not yet fo well examined and digested as to propound for Axioms, but only as Queries and Conjectures which may ferve as hints toward fome further discoveries. As first, Upon the confideration of the congruity and incongruity of Bodies, as to touch, I found alfo the like congruity and incongruity (if I may fo speak) as to the Transmitting of the Raies of Light : For as in this regard, mater (not now to mention other Liquors) feems nearer of affinity to Glass then Air, and Air then Quicksilver : whence an oblique Ray out of Glass, will pass into mater with very little refraction from the perpendienlar, but none out of Glass into Air, excepting a direct, will pass without a very great refraction from the perpendicular, nay any oblique Ray under thirty degrees, will not be admitted into the Air at all. And Quickfilver will neither admit oblique or direct, but reflects all ; feeming, as to the transmitting of the Raies of Light, to be of a quite differing constitution, from that of Air, Water, Glass, O.c. and to refemble most those opacous and strong reflecting bodies of Metals: So also as to the property of cohefion or congruity, Water feems to keep the fame order, being more

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more congruous to Glafs then Air, and Air then Quickfilver.

A Second thing (which was hinted to me, by the confideration of the included fluids globular form, caufed by the protrusion of the ambient heterogeneous fluid) was, whether the Phanomena of gravity might not by this means be explained, by supposing the Globe of Earth, Water, and Air to be included with a fluid, heterogeneous to all and each of them, fo fubtil, as not only to be every where interspersed through the Air, (or rather the air through it) but to pervade the bodies of Glass, and even the closeft Metals, by which means it may endeavour to detrude all earthly bodies as far from it as it can; and partly thereby, and partly by other of its properties may move them towards the Center of the Earth. Now that there is fome fuch fluid, I could produce many Experiments and Reafons, that do feem to prove it : But becaufe it would ask fome time and room to let them down and explain them, and to confider and answer all the Objections (many whereof I forefee) that may be alledged against . it; I shall at present proceed to other Queries, contenting my felf to have here only given a hint of what I may fay more elfwhere.

A Third Query then was, Whether the heterogeneity of the ambient fluid may not be accounted a fecondary caufe of the roundnefs or globular form of the greater bodies of the world, fuch as are those of the Sun, Stars, and Planets, the fubstance of each of which seems altogether heterogeneous to the circum-ambient fluid ather? And of this I shall fay more in the Observation of the Moon.

A Fourth was, Whether the globular form of the fmaller parcels of matter here upon the Earth, as that of Fruits, Pebbles, or Flints, &c. (which feem to have been a Liquor at first) may not be caufed by the beterogeneous ambient fluid. For thus we fee that melted Glass will be naturally formed into a round Figure; fo likewife any fmall Parcel of any fufible body, if it be perfectly enclosed by the Air, will be driven into a globular Form; and, when cold, will be found a folid Ball. This is plainly enough manifested to us by their way of making flot with the drops of Lead; which being a very pretty curiofity, and known but to a very few, and having the liberty of publishing it granted me, by that Eminent Virtuoso Sir Rabert Moray, who brought in this Account of it to the Royal Society, I have here transcribed and inferted.

To make fmall fhot of different fizes; Communicated by his Highnefs P. R.

Ake Lead out of the Pig what quantity you please, melt it down, ftir and clear it with an iron Ladle, gathering together the blackish parts that swim at top like scum, and when you see the colour of the clear Lead to be greenish, but no sooner, strew upon it Auripigmentum

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pigmentum powdered according to the quantity of Lead, about as much as will lye upon a half Crown piece will serve for eighteen or twenty pound weight of some forts of Lead; others will require more, or les. After the Auripigmentum is put in, für the Lead well, and the Auripigmentum will flame : when the flame is over, take out some of the Lead in a Ladle having a lip or notch in the brim for convenient pouring out of the Lead, and being well warmed among ft the melted Lead, and with a flick make some single drops of Lead trickle out of the Ladle into water in a Glass, which if they fall to be round and without tails, there is Auripigmentum enough put in, and the temper of the heat is right, otherwife put in more. Then lay two bars of Iron (or some more proper Iron-tosl made on purpose) upon a Pail of water, and place upon them a round Plate of Copper, of the fize and figure of an ordinary large Pewter or Silver Trencher, the hollow whereof is to be about three inches over, the bottom lower then the brims about half an inch, pierced with thirty, forty, or more small holes; the smaller the holes are, the smaller the shot will be; and the brim is to be thicker then the bottom, to conferve the heat the better. be moletand of Only Gree

The bottom of the Trencher being some four inches distant frum the water in the Pail, lay upon it fome burning Coles, to keep the Lead melted upon it. Then with the hot Ladle take Lead off the Pot where it flands melted, and pour it foftly upon the burning Coles over the bottom of the Trencher, and it will immediately run through the holes into the water in finall round drops. Thus pour on new Lead still as fast as it runs through the Trencher till all be done; blowing now and then the Coles with hand-Bellows, when the Lead in the Trencher cools fo as to fiop from running. Whilft one pours on the Lead, another must, with another Ladle, thrusted four or five inches under water in the Pail, catch from time to time fome of the flot, as it drops down, to fee the fize of it, and whether there be any faults in it. The greatest care is to keep the Lead upon the Trencher in the right degree of heat; if it be too cool, it will not run through the Trencher, though it stand melted upon it; and this is to be

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be helped by blowing the Coals a little, or pouring on new Lead that is hotter: but the cooler the Lead, the larger the Shot; and the hotter, the fmaller; when it is too hot, the drops will crack and fly; then you must stop pouring on new Lead, and let it cool; and so long as you obferve the right temper of the heat, the Lead will constantly drop into very round Shot, without so much as one with a tail in many pounds.

When all is done, take your Shot out of the Pail of water, and put it in a Frying-pan over the fire to dry them, which must be done warily, ftill shaking them that they melt not; and when they are dry you may separate the small from the great, in Pearl Sives made of Copper or Lattin let into one another, into as many sizes as you please. But if you would have your Shot larger then the Trencher makes them, you may do it with a Stick, making them trickle out of the Ladle, as bath been said.

If the Trencher be but toucht a very little when the Lead flops from going through it, and be not too cool, it will drop again, but it is better not to touch it at all. At the melting of the Lead take care that there be no kind of Oyl, Greafe, or the like, upon the Pots, or Ladles, or Trencher.

The Chief caufe of this Globular Figure of the Shot, feems to be the Auripigmentum; for, as foon as it is put in among the melted Lead, it lofes its fhining brightnefs, contracting inftantly a grayifh film or skin upon it, when you four it to make it clean with the Ladle. So that when the Air comes at the falling drop of the melted Lead, that

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skin confiricts them every where equally: but upon what account, and whether this be the true cause, is left to further disquisition,

Much after this fame manner, when the Air is exceeding cold through which it paffes, do we find the drops of Rain, falling from the Clouds, congealed into round Hail-ftones by the freezing Ambient.

To which may be added this other known Experiment, That if you gently let fall a drop of *water* upon fmall *fand* or *duft*, you fhall find, as it were, an artificial *round ftone* quickly generated. I cannot upon this occafion omit the mentioning of the ftrange kind of *Grain*, which I have obferved in a *ftone* brought from *Kettering* in *Northamptonfhire*, and therefore called by Mafons *Kettering-Stone*, of which fee the Defcription. Which

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Which brings into my mind what I long fince obferved in the fiery Sparks that are ftruck out of a Steel. For having a great defire to fee what was left behind, after the Spark was gone out, I purpofely ftruck fire over a very white piece of Paper, and obferving diligently where fome confpicuous fparks went out, I found a very little black fpot no bigger then the point of a Pin, which through a *Microfcope* appeared to be a perfectly round Ball, looking much like a polifht ball of Steel, infomuch that I was able to fee the Image of the window reflected from it. I cannot here ftay (having done it more fully in another place) to examine the particular Reafons of it, but fhall only hint, that I imagine it to be fome fmall parcel of the Steel, which by the violence of the motion of the ftroke (moft of which feems to be impreft upon thofe fmall parcels) is made fo glowing hot, that it is melted into a Vitrum, which by the ambient Air is thruft into the form of a Ball.

A Fifth thing which I thought worth Examination was, Whether the motion of all kind of Springs, might not be reduced to the Principle whereby the included *heterogeneous fluid* feems to be moved; or to that whereby two Solids, as Marbles, or the like, are thruft and kept together by the *ambient fluid*.

A Sixth thing was, Whether the Rifing and Ebullition of the Water out of Springs and Fountains (which lie much higher from the Center of the Earth then the Superficies of the Sea, from whence it feems to be derived) may not be explicated by the rifing of Water in a smaller Pipe: For the Sea-water being strained through the Pores or Crannies of the Earth, is, as it were, included in little Pipes, where the preflure of the Air has not fo great a power to refift its rifing : But examining this way, and finding in it feveral difficulties almost irremovable, I thought upon a way that would much more naturally and conceivably explain it, which was by this following Experiment: I took a Glass-Tube, of the form of that described in the fixth Figure, and chusing two heterogeneous fluids, such as Water and Oyl, I poured in as much Water as filled up the Pipes as high as A B, then putting in fome Oyl into the Tube A C, I deprest the superficies A of the Water to E, and B I raifed to G, which was not fo high perpendicularly as the fuperficies of the Oyl F, by the fpace F I, wherefore the proportion of the gravity of these two Liquors was as GH to FE. This Experiment I tried with feveral other Liquors, and particularly with fresh Water and Salt (which I made by diffolving Salt in warm Water) which two though they are nothing heterogeneous, yet before they would perfectly mix one with another, I made trial of the Experiment: Nay, letting the Tube wherein I tried the Experiment remain for many dayes, I observed them not to mix; but the superficies of the fresh was rather more then lefs elevated above that of the Salt. Now the proportion of the gravity of Sea-water, to that of River-water, according to stevinus and Varenius, and as I have fince found pretty true by making trial my felf, is as 46. to 45. that is, 46. Ounces of the falt Water

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ter will take up no more room then 45. of the fresh. Or reciprocally 45 pints of falt-water weigh as much as 46 of fresh.

But I found the proportion of Brine to fresh Water to be near 13 to 12: Supposing therefore G H M to represent the Sea, and F I the height of the Mountain above the Superficies of the Sea, FM a Cavern in the Earth, beginning at the bottom of the Sea, and terminated at the top of the Mountain, L M the Sand at the bottom, through which the Water is as it were strained, so as that the fresher parts are only permitted to transude, and the faline kept back ; if therefore the proportion of G M to F M be as 45 to 46, then may the Cylinder of Salt-water G M make the Cylinder of Fresh-water to rife as high as E, and to run over at N. I cannot here ftand to examine or confute their Opinion, who make the depth of the Sea, below its Superficies, to be no more perpendicularly measured then the height of the Mountains above it: 'Tis enough for me to fay, there is no one of those that have afferted it, have experimentally known the perpendicular of either; nor fhall I here determine, whether there may not be many other causes of the separation of the fresh water from the falt, as perhaps fome parts of the Earth through which it is to pafs, may contain a Salt, that mixing and uniting with the Sea-falt, may precipitate it; much after the fame manner as the Alkalizate and Acid Salts mix and precipitate each other in the preparation of Tartarum Vitriolatum. I know not alfo whether the exceeding cold (that must necessarily be) at the bottom of the Water, may not help towards this feparation, for we find, that warm Water is able to diffolve and contain more Salt, then the fame cold; infomuch that Brines ftrongly impregnated by heat, if let cool, do fuffer much of their Salt to fubfide and crystallize about the bottom and fides. I know not also whether the exceeding preffure of the parts of the Water one against another, may not keep the Salt from defcending to the very bottom, as finding little or no room to infert it felf between those parts, protruded fo violently together, or elfe squeeze it upwads into the superiour parts of the Sea, where it may more eafily obtain room for it felf, amongft the parts of the Water, by reason that there is more heat and less pressure. To this Opinion I was fomewhat the more induced by the relations I have met with in Geographical Writers, of drawing fresh Water from the bottom of the Sea, which is falt above. I cannot now stand to examine, whether this natural perpetual motion may not artificially be imitated : Nor can I stand to answer the Objections which may be made against this my Supposition : As, First, How it comes to pass, that there are sometimes falt Springs much higher then the Superficies of the Water? And, Secondly, Why Springs do not run faster and flower, according to the varying height made of the Cylinder of Sea-water, by the ebbing and flowing of the Sea? many dayes, I objerved them not to mix a but th

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As to the First, In short, I say, the fresh Water may receive again a saline Tincture near the Superficies of the Earth, by passing through some saline forme should be many of the saline parts of the Sea may be kept back, though not all.

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And as to the Second, The fame Spring may be fed and supplyed by divers Caverns, coming from very far diftant parts of the Sea, fo as that it may in one place be high, in another low water; and fo by that means the spring may be equally supply'd at all times. Or elfe the Cavern may be fo ftraight and narrow, that the water not having fo ready and free paflage through it, cannot upon to fhort and quick mutations of preffure, be able to produce any fenfible effect at fuch a distance. Besides that, to confirm this hypothesis, there are many Examples found in Natural Historians, of Springs that do ebb and flow like the Sea : As particularly, those recorded by the Learned Camden, and after him by speed, to be found in this Island : One of which, they relate to be on the Top of a Mountain, by the small Village Kilken in Flintshire, Maris amulus qui statis temporibus fuas evomit & reforbet Aquas; Which at certain times rifeth and falleth after the manner of the Sea. A Second in Caermardenshire, near Caermarden, at a place called Cantred Bichan; Qui (ut scribit Giraldus) naturali die bis undis deficiens, & toties exuberans, marinas imitatur instabilitates; That twice in four and twenty hours ebbing and flowing, refembleth the unftable motions of the Sea. The Phanomena of which two may be eafily made out, by fuppoling the Cavern, by which they are fed, to arife from the bottom of the next Sea. A Third, is a Well upon the River Ogmore in Glamorganshire, and near unto Newton, of which Camden relates himfelf to be certified, by a Letter from a Learned Friend of his that observed it, Fons abest hinc, O.c. The Letter is a little too long to be inferted, but the fubftance is this ; That this Well ebbs and flows quite contrary to the flowing and ebbing of the Sea in those parts : for 'tis almost empty at Full Sea, but full at Low water. This may happen from the Channel by which it is supplied, which may come from the bottom of a Sea very remote from those parts, and where the Tides are much differing from those of the approximate shores. A Fourth, lies in Westmorland, near the River Loder ; Qui instar Euripi sepius in die reciprocantibus undis fluit & refluit, which ebbs and flows many times a day. This may proceed from its being supplyed from many Channels, coming from leveral parts of the Sea, lying sufficiently distant asunder to have the times of High-water differing enough one from the other; fo as that when loever it shall be High water over any of those places, where these Channels begin, it shall likewise be so in the Well; but this is but a suppofition. A Seventh Query was, Whether the diffolution or mixing of feveral bodies, whether fluid or folid, with faline or other Liquors, might not partly be attributed to this Principle of the congruity of those bodies and their diffolvents? As of Salt in Water, Metals in feveral Menstruums, Unctuous Gums in Oyls, the mixing of Wine and Water, O.c. And whether precipitation be not partly made from the fame Principle of Incongruity? I fay partly, because there are in some Diffolutions, some other Causes concurrent. I shall lastly make a much more feemingly strange and unlikely Query ; and that is, Whether this Principle, well examined and explained, may not

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not be found a co-efficient in the most confiderable Operations of Nature? As in those of Heat, and Light, and confequently, of Rarefaction and Condensation, Hardness, and Fluidness, Perspicuity and Opacousness, Refractions and Colours, O.c. Nay, I know not whether there may be many things done in Nature, in which this may not (be faid to) have a Finger? This I have in some other passages of this Treatise further enquired into and shewn, that as well Light as Heat may be caused by corrosion, which is applicable to congruity, and confequently all the reft will be but subsequents: In the mean time I would not willingly be guilty of that Error, which the thrice Noble and Learned Verulam justly takes notice of, as fuch, and calls Philosophiæ Genus Empiricum, quod in paucorum Experimentorum Angustiis O Obscuritate fundatum est. For I neither conclude from one fingle Experiment, nor are the Experiments I make use of all made upon one Subject : Nor wreft I any Experiment to make it quadrare with any preconceiv'd Notion. But on the contrary, I endeavour to be converfant in divers kinds of Experiments, and all and every one of those Trials, I make the Standards or Touchstones, by which I try all my former Notions, whether they hold out in weight, and measure, and touch, O.c. For as that Body is no other then a Counterfeit Gold, which wants any one of the Proprieties of Gold, (fuch as are the Malleablenefs, Weight, Colour, Fixtnefs in the Fire, Indiffolubleness in Aqua fortis, and the like) though it has all the other; fo will all those Notions be found to be false and deceitful, that will not undergo all the Trials and Tefts made of them by Experiments. And therefore fuch as will not come up to the defired Apex of Perfection, I rather wholly reject and take new, then by piecing and patching, endeavour to retain the old, as knowing fuch things at beft to be but lame and imperfect. And this course I learned from Nature; whom we find neglectful of the old Body, and fuffering its Decaies and Infirmities to remain without repair, and altogether follicitous and careful of perpetuating the species by new Individuals. And it is certainly the most likely way to crect a glorious Structure and Temple to Nature, fuch as fhe will be found (by any zealous Vetary) to refide in; to begin to build a new upon a fure Foundation of Experiments.

But to digrefs no further from the confideration of the *Phanomena*, more immediately explicable by this Experiment, we fhall proceed to fhew, That, as to the rifing of Water in a *Filtre*, the reafon of it will be manifeft to him, that does take notice, that a *Filtre* is conftituted of a great number of fmall long folid bodies, which lie fo clofe together, that the Air in its getting in between them, doth lofe of its preflure that it has againft the *Fluid* without them, by which means the Water or Liquor not finding fo ftrong a refiftance between them as is able to counter-ballance the preflure on its fuperficies without, is raifed upward, till it meet with a preflure of the Air which is able to hinder it. And as to the Rifing of Oyl, melted Tallow, Spirit of Wine, *&c.* in the Week of a Candle or Lamp, it is evident, that it differs in nothing from the former, fave only in this, that in a *Filtre* the Liquor defcends and runs away by another part; and in the Week the Liquor is difperfed and carried away by the Flame 3

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Flame; fomething there is afcribable to the Heat, for that it may rarifie the more volatil and fpirituous parts of those combustible Liquors, and fo being made lighter then the Air, it may be protruded upwards by that more ponderous fluid body in the Form of Vapours; but this can be afcribed to the afcension of but a very little, and most likely of that only which afcends without the Week. As for the Rising of it in a Spunge, Bread, Cotton. &c. above the superficies of the subjacent Liquor; what has been faid about the Filtre (if confidered) will easily suggest a reason, confidering that all these bodies abound with subjacent pores.

From this fame Principle also (viz. the unequal pressure of the Air against the unequal superficies of the water) proceeds the cause of the acceffion or incursion of any floating body against the fides of the containing Vefiel, or the appropinquation of two floating bodies, as Bubbles, Corks, Sticks, Strams, O.c. one towards another. As for instance, Take a Glass-jar, fuch as A B in the seventh Figure, and filling it pretty near the top with water, throw into it a small round piece of Cork, as C, and plunge it all over in water, that it be wet, fo as that the water may rife up by the fides of it, then placing it any where upon the fuperficies, about an inch,or one inch and a quarter from any fide, and you shall perceive it by degrees to make perpendicularly toward the nearest part of the fide, and the nearer it approaches, the faster to be moved; the reason of which Phanomenon will be found no other then this, that the Air has a greater preffure against the middle of the superficies, then it has against those parts that approach nearer, and are contiguous to the fides. Now that the preflure is greater, may (as I shewed before in the explication of the third Figure) be evinced from the flatting of the water in the middle, which arifes from the gravity of the under fluid: for fince, as I fhewed before, if there were no gravity in the under fluid, or that it were equal to that of the upper, the terminating Surface would be spherical, and fince it is the additional preffure of the gravity of water that makes it fo flat, it follows, that the preffure upon the middle must be greater then towards the fides. Hence the Ball having a ftronger preffure against that fide of it which respects the middle of the superficies, then against that which respects the approximate fide, must necessarily move towards that part, from whence it finds least refistance, and so be accelerated, as the refiftance decreases. Hence the more the water is raised under that part of its way it is paffing above the middle, the faster it is moved : And therefore you will find it to move faster in E then in D, and in D then in C. Neither could I find the floating substance to be moved at all, until it were placed upon fome part of the Superficies that was fentibly elevated above the height of the middle part. Now that this may be the true caufe, you may try with a blown Bladder, and an exactly round Ball upon a very fmooth fide of fome pliable body, as Horn or Quicksilver. For if the Ball be placed under a part of the Bladder which is upon one fide of the middle of its preffure, and you prefs ftrongly against the Bladder, you shall find the Ball moved from the middle towards the fides. Having

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Having therefore shewn the reason of the motion of any float towards the fides, the reason of the incursion of any two floating bodies will easily appear : For the rifing of the water against the fides of either of them, is an Argument fufficient, to fhew the preflure of the Air to be there lefs, then it is further from it, where it is not fo much elevated ; and therefore the reason of the motion of the other toward it, will be the same as towards the fide of the Glass; only here from the same reason, they are mutually moved toward each other, whereas the fide of the Glass in the former remains fixt. If also you gently fill the Jar fo full with water, that the water is protuber ant above the fides, the fame piece of Cork that before did haften towards the fides, does now fly from it as fast towards the middle of the Superficies; the reafon of which will be found no other then this, that the preffure of the Air is ftronger against the fides of the Superficies G and H, then against the middle I; for fince, as I shewed before, the Principle of congruity would make the terminating Surface Spherical, and that the flatting of the Surface in the middle is from the abatement of the waters preffure outwards, by the contrary indeavour of its gravity ; it follows that the preflure in the middle must be less then on the fides; and therefore the confecution will be the fame as in the former. It is very odd to one that confiders not the reason of it, to see two floating bodies of wood to approach each other, as though they were indued with fome magnetical vigour ; which brings into my mind what I formerly tried with a piece of Cork or fuch like body, which I fo ordered, that by putting a little stick into the same water, one part of the said Cork would approach and make toward the flick, whereas another would difcede and fly away, nay it would have a kind of verticity, fo as that if the Æquator (as I may fo speak) of the Cork were placed towards the stick, if let alone, it would instantly turn its appropriate Pole toward it, and then run a-tilt at it: and this was done only by taking a dry Cork, and wetting one fide of it with one fmall stroak; for by this means gently putting it upon the water, it would deprefs the superficies on every fide of it that was dry, and therefore the greatest pressure of the Air, being near those fides caused it either to chase away, or else to fly off from any other floating body, whereas that fide only, against which the water ascended, was thereby able to attract. It remains only, that I fhould determine how high the Water or other Liquor may by this means be raifed in a smaller Pipe above the Superficies of that without it, and at what height it may be fustained : But to determine this, will be exceeding difficult, unless I could certainly know how much of the Airs preflure is taken off by the fmalnefs of fuch and fuch a Pipe, and whether it may be wholly taken off, that is, whether there can be a hole or pore fo fmall, into which Air could not at all enter, though water might with its whole force; for were there fuch, 'tis manifeft, that the water might rife in it to fome five or fix and thirty English Foot high. I know not whether the capillary Pipes in the bodies of fmall Trees, which we call their Microfcopical pores, may not be fuch; and whether the congruity of the fides of the Pore may not yet draw the juyce even

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even higher then the Air was able by its bare preffure to raife it : For, Congruity is a principle that not only unites and holds a body joyned to it, but, which is more, attracts and draws a body that is very near it, and holds it above its usual height.

And this is obvious even in a drop of water fuspended under any Similar or Congruous body : For, befides the ambient prefiure that helps to keep it fustein'd, there is the Congruity of the bodies that are contiguous. This is yet more evident in Tenacious and Glutinous bodies; fuch as Gummous Liquors, Syrups, Pitch, and Rofin melted, &c. Tar, Turpentine, Balfom, Bird-lime, Oc. for there it is evident, that the Parts of the tenacious body, as I may fo call it, do ftick and adhere fo clofely together, that though drawn out into long and very flender Cylinders, yet they will not eafily relinquish one another; and this, though the bodies be aliquatenus fluid, and in motion by one another; which, to fuch as confider a fluid body only as its parts are in a confused irregular motion, without taking in also the congruity of the parts one among another, and incongruity to some other bodies, does appear not alittle strange. So that befides the incongruity of the ambient fluid to it, we are to confider also the congruity of the parts of the contein'd fluid one with another.

And this Congruity (that I may here a little further explain it) is both a Tenaceous and an Attractive power; for the Congruity, in the Vibrative motions, may be the caufe of all kind of attraction, not only Electrical, but Magnetical alfo, and therefore it may be alfo of Tenacity and Glutinousnels. For, from a perfect congruity of the motions of two distant bodies, the intermediate fluid particles are separated and droven away from between them, and thereby those congruous bodies are, by the incompaffing mediums, compell'd and forced neerer together; wherefore that attractivenels must needs be stronger, when, by an immediate contact, they are forc'd to be exactly the fame: As I fhew more at large in my Theory of the Magnet. And this hints to me the reason of the suspension of the Mercury many inches, nay many feet, above the usual station of 30 inches. For the parts of Quick-filver, being fo very fimilar and congruous to each other, if once united, will not eafily fuffer a divulsion : And the parts of water, that were any wayes heterogeneous, being by exantlation or rarefaction exhausted, the remaining parts being alfo very fimilar, will not eafily part neither. And the parts of the Glafs being folid, are more difficultly disjoyn'd; and the water, being fomewhat fimilar to both, is, as it were, a medium to unite both the Glass and the Mercury together. So that all three being united, and not very diffimilar, by means of this contact, if care be taken that the Tube in erecting be not shogged, the Quicksilver will remain suspended, notwithstanding its contrary indeavour of Gravity, a great height above its ordinary Station; but if this immediate Contact be removed, either by a meer feparation of them one from another by the force of a flog, whereby the other becomes imbodied between them, and licks up from the furface some agil parts, and so hurling them makes them air; or else VIDIONS by

by fome fmall heterogeneous agil part of the Water, or Air, or Quickfilver, which appears like a bubble, and by its jumbling to and fro there is made way for the heterogeneous Æther to obtrude it felf between the Glass and either of the other Fluids, the Gravity of Mercury precipitates it downward with very great violence ; and if the Veffel that holds the restagnating Mercury be convenient, the Mercury will for a time vibrate to and fro with very large reciprocations, and at last will remain kept up by the prefiure of the external Air at the height of neer thirty inches. And whereas it may be objected, that it cannot be, that the meer imbodying of the Æther between these bodies can be the cause, fince the Æther having a free paffage alwayes, both through the Pores of the Glafs, and through those of the Fluids, there is no reason why it should not make a feparation at all times whilft it remains suspended, as when it is violently dif-joyned by a shog. To this I answer, That though the Æther passes between the Particles, that is, through the Pores of bodies, fo as that any chasme or separation being made, it has infinite passages to admit its entry into it, yet fuch is the tenacity or attractive virtue of Congruity, that till it be overcome by the meer strength of Gravity, or by a shog assisting that Conatus of Gravity, or by an agil Particle, that is like a leaver agitated by the Ætber; and thereby the parts of the congruous substances are separated so far asunder, that the strength of congruity is so far weakened, as not to be able to reunite them, the parts to be taken hold of being removed out of the attractive Sphere, as I may fo speak, of the congruity; fuch, I fay, is the tenacity of congruity, that it retains and holds the almost contiguous Particles of the Fluid, and suffers them not to be separated, till by meer force that attractive or retentive faculty be overcome: But the separation being once made beyond the Sphere of the attractive activity of congruity, that virtue becomes of no effect at all, but the Mercury freely falls downwards till it meet with a refiftance from the preffure of the ambient Air, able to refift its gravity, and keep it forced up in the Pipe to the height of about thirty inches.

Thus have I gently raifed a Steel pendulum by a Loadstone to a great Angle, till by the fhaking of my hand I have chanced to make a feparation between them, which is no fooner made, but as if the Loadstone had retained no attractive virtue, the Pendulum moves freely from it towards the other fide. So vaft a difference is there between the attractive virtue of the Magnet when it acts upon a contiguous and upon a disjoyned body: and much more must there be between the attractive virtues of congruity upon a contiguous and disjoyned body 3 and in truth the attra-Etive virtue is fo little upon a body disjoyned, that though I have with a Microscope observed very diligently, whether there were any extraordinary protuberance on the fide of a drop of water that was exceeding neer to the end of a green flick, but did not touch it, I could not perceive the leaft; though I found, that as foon as ever it toucht it the whole drop would prefently unite it felf with it; fo that it feems an absolute contact is requifite to the exercifing of the tenacious faculty of congruity. of brist.

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Observ. VII. Of some Phanomena of Glass drops.

Thefe Glass Drops are finall parcels of coarfe green Glasstaken out of the Pots that contain the Metal (as they call it) in fusion, upon the end of an Iron Pipe; and being exceeding hot, and thereby of a kind of fluggish fluid Consistence, are suffered to drop from thence into a Bucket of cold Water, and in it to lye till they be grown sensibly cold.

Some of thefe I broke in the open air, by fnapping off a little of the fmall ftem with my fingers, others by crufhing it with a fmall pair of Plyers; which I had no fooner done, then the whole bulk of the drop flew violently, with a very brisk noife, into multitudes of fmall pieces, fome of which were as fmall as duft, though in fome there were remaining pieces pretty large, without any flaw at all, and others very much flaw'd, which by rubbing between ones fingers was eafily reduced to duft; thefe difperfed every way fo violently, that fome of them pierced my skin. I could not find, either with my naked Eye, or a *Microfcope*, that any of the broken pieces were of a regular figure, nor any one like another, but for the moft part those that flaw'd off in large pieces were prettily branched.

The ends of others of these drops I nipt off whilst all the bodies and ends of them lay buried under the water, which, like the former, flew all to pieces with as brisk a noise, and as strong a motion.

Others of these I tried to break, by grinding away the blunt end, and though I took a feemingly good one, and had ground away neer two thirds of the Ball, yet would it not fly to pieces, but now and then fome fmall rings of it would map and fly off, not without a brisk noise and quick motion, leaving the Surface of the drop whence it flew very prettily branched or creafed, which was eafily discoverable by the Microscope. This drop, after I had thus ground it, without at all impairing the remnant that was not ground away, I caufed to fly immediately all into fand upon the nipping off the very tip of its flender end. Another of these drops I began to grind away at the smaller end, but had not worn away on the ftone above a quarter of an inch before the whole drop flew with a brisk crack into fand or fmall duft; nor would it have held fo long, had there not been a little flaw in the piece that I ground away, as I afterwards found. Several others of these drops I covered over with a thin but very tuff skin of Icthyocolla, which being very tough and very transparent, was the most convenient substance for these tryals that I could imagine, having dipt,I fay, feveral of these drops in this transparent Glue whilst hot, and fuffering them to hang by a ftring tied about the end of them till they were cold, and the skin pretty tough; then wrapping all the body of the drop G

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drop (leaving out only the very tip) in fine fupple Kids-leather very clofely, I nipped off the fmall top, and found, as I expected, that notwithftanding this skin of Glue, and the clofe wrapping up in Leather, upon the breaking of the top, the drop gave a crack like the reft, and gave my hand a pretty brisk impulfe: but yet the skin and leather was fo ftrong as to keep the parts from flying out of their former pofture; and, the skin being transparent, I found that the drop retained exactly its former figure and polifh, but was grown perfectly opacous and all over flaw'd, all those flaws lying in the manner of rings, from the bottom or blunt end, to the very top or fmall point. And by several examinations with a *Microfcope*, of several thus broken, I found the flaws, both within the body of the drop, and on the outward furface, to lye much in this order.

Let A B in the Figure X of the fourth Scheme represent the drop cafed over with IEthyocolla or Isinglass, and (by being ordered as is before prefcribed) crazed or flawed into pieces, but by the skin or cafe kept in its former figure, and each of its flawed parts preferved exactly in its due posture; the outward appearance of it fomewhat plainly to the naked eye, but much more conspicuous if viewed with a small sens appeared much after this shape. That is, the blunt end B for a pretty breadth, namely, as far as the Ring CCC feemed irregularly flawed with divers clefts, which all feemed to tend towards the Center of it, being, as I afterwards found, and shall anon shew in the description of the figure Y, the Basis, as it were, of a Cone, which was terminated a little above the middle of the drop, all the reft of the Surface from CCC to A was flawed with an infinite number of fmall and parallel Rings, which as they were for the most part very round, fo were they very thick and close together, but were not so exactly flaw'd as to make a perfect Ring, but each circular part was by irregular cracks flawed likewife into multitudes of irregular flakes or tiles; and this order was observed likewise the whole length of the neck,

Now though I could not fo exactly cut this conical Body through the Axis, as is reprefented by the figure Y; yet by anatomizing, as it were, of feveral, and taking notice of divers particular circumstances, I was informed, that could I have artificially divided a flaw'd drop through the Axis or Center, I should with a Microscope have found it to appear much of this form, where A fignifies the Apex, and B the blunt end, CC the Cone of the Basis, which is terminated at T the top or end of it, which feems to be the very middle of the blunt end, in which, not only the conical body of the Bafis CC is terminated, but as many of the parts of the drop as reach as high as DD. And it feemed to be the head or beginning of a Pith, as it were, or a a part of the body which feemed more fpungy then the reft, and much more irregularly flawed, which from T afcended by EE, though lefs vifible, into the small neck towards A. The Grain, as it were, of all the flaws, that from all the outward Surface A DCCDA, was much the fame, as is reprefented by the black ftrokes that meet in the middle DT, DT, DE, DE, Oc.

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Nor is this kind of Grain, as I may call it, peculiar to Glafs drops thus quenched; for (not to mention *Coperas-fromes*, and divers other *Marchafites* and *Minerals*, which I have often taken notice of to be in the very fame manner flaked or grained, with a kind of Pith in the middle) I have observed the fame in all manner of caft Iron, especially the coarfer fort, fuch as Stoves, and Furnaces, and Backs, and Pots are made of: For upon the breaking of any of those Substances it is obvious to obferve, how from the out-fides towards the middle, there is a kind of Radiation or Grain much refembling this of the Glafs-drop; but this Grain is most conspicuous in Iron-bullets, if they bebroken: the fame *Phanomena* may be produced by casting *regulus* of *Antimony* into a Bullet-mold, as also with *Glass of Antimony*, or with almost any such kind of *Vitrified fubstance*, either cast into a cold Mold or poured into Water.

Others of these Drops I heat red hot in the fire, and then suffered them to cool by degrees. And these I found to have quite lost all their *fulminating* or flying quality, as also their hard, brittle and springy texture; and to emerge of a much softer temper, and much easier to be broken or snapt with ones finger; but its strong and brittle quality was quite destroyed, and it seemed much of the same confistence with other green Glass well nealed in the Oven.

The Figure and bigness of these for the most part was the same with that of the Figure Z; that is, all the furface of them was very fmooth and polifht, and for the most part round, but very rugged or knobbed about D, and all the length of the ftem was here and there pitted or flatted. About D, which is at the upper part of the drop under that fide of the ftem which is concave, there ufually was made fome one or more little Hillocks or Prominences. The drop it felf, before it be broken, appears very transparent, and towards the middle of it, to be very full of small Bubbles, of fome kind of aerial fubftance, which by the refraction of the outward furface appear much bigger then really they are; and this may be in good part removed, by putting the drop under the furface of clear Water, for by that means most part of the refraction of the convex Surface of the drop is destroyed, and the bubbles will appear much smaller. And this, by the by, minds me of the appearing magnitude of the aperture of the iris, or pupil of the eye, which though it appear, and be therefore judged very large, is yet not above a quarter of the bignefs it appears of, by the lenticular refraction of the Cornea. The caufe of all which Phanomena I imagine to be no other then this, That the Parts of the Glass being by the excessive heat of the fire kept off and separated one from another, and thereby put into a kind of fluggifh fluid confiftence, are fuffered to drop off with that heat or agitation remaining in them, into cold Water; by which means the outfides of the drop are prefently cool'd and crusted, and are thereby made of a loofe texture, becaufe the parts of it have not time to fettle themfelves leifurely together, and fo to lie very close together: And the innermolt parts of the drop, retaining still much of their former heat and agitations, remain of G 2

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of a loofe texture also, and, according as the cold strikes inwards from the bottom and fides, are quenched, as it were, and made rigid in that very posture wherein the cold finds them. For the parts of the *crust* being already hardened, will not fuffer the parts to shrink any more from the outward Surface inward; and though it shrink a little by reason of the simall parcels of some Aerial substances dispersed through the matter of the Glass, yet that is not neer so much as it appears (as I just now hinted;) nor if it were, would it be sufficient for to consolidate and condense the body of Glass into a *tust* and close *texture*, after it had been so exceffively rarified by the heat of the glass-Furnace.

But that there may be fuch an expansion of the aerial substance contained in those little blebbs or bubbles in the body of the drop, this following Experiment will make more evident.

Take a small Glass-Cane about a foot long, feal up one end of it hermetically, then put in a very small bubble of Glass, almost of the shape of an Effence-viol with the open mouth towards the fealed end, then draw out the other end of the Pipe very fmall, and fill the whole Cylinder with water, then fet this Tube by the Fire till the Water begin to boyl, and the Air in the bubble be in good part rarified and driven out, then by fucking at the fmalling Pipe, more of the Air or vapours in the bubble may be fuck'd out, fo that it may fink to the bottom; when it is funk to the bottom, in the flame of a Candle, or Lamp, nip up the flender Pipe and let it cool: whereupon it is obvious to observe, first, that the Water by degrees will subside and shrink into much lefs room : Next, that the Air or vapours in the Glass will expand themselves fo, as to buoy up the little Glafs: Thirdly, that all about the infide of the Glafs-pipe there will appear an infinite number of fmall bubbles, which as the Water grows colder and colder will fwell bigger and bigger, and many of them buoy themfelves up and break at the top.

From this Difceding of the heat in Glass drops, that is, by the quenching or cooling Irradiations propagated from the Surface upwards and inwards, by the lines CT, CT, DT, DE, Oc. the bubbles in the drop have room to expand themfelves a little, and the parts of the Glafs contract themselves; but this operation being too quick for the fluggish parts of the Glais, the contraction is performed very unequally and irregularly, and thereby the Particles of the Glassare bent, some one way, and some another, yet fo as that most of them draw towards the Pithor middle TEEE, or rather from that outward : fo that they cannot extricate or unbend themfelves, till fome part of TEEE be broken and loofened, for all the parts about that are placed in the manner of an Arch, and fo till their hold at TEEE be loofened they cannot fly afunder, but uphold, and fhelter, and fix each other much like the ftones in a Vault, where each ftone does concurre to the ftability of the whole Fabrick, and no one ftone can be taken away but the whole Arch falls. And wherefoever any of those radiating wedges DT D, &c. are removed, which are the component parts of this Arch, the whole Fabrick prefently falls to pieces ;

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pieces; for all the Springs of the feveral parts are fet at liberty, which immediately extricate themfelves and fly afunder every way; each part by its fpring contributing to the darting of it felf and fome other contiguous part. But if this drop be heat fo hot as that the parts by degrees can unbend themfelves, and be fettled and annealed in that pofture, and be then fuffered gently to fubfide and cool; The parts by this nealing lofing their fpringinefs, conftitute a drop of a more foft but lefs brittle texture, and the parts being not at all under a flexure, though any part of the middle or Pith T E E E be broken, yet will not the drop at all fly to pieces as before.

This Conjecture of mine I shall indeavour to make out by explaining each particular Assertion with analogous Experiments: The Assertions are these.

First, That the parts of the Glass, whilst in a fluid Confistence and hot, are more rarified, or take up more room, then when hard and cold.

Secondly, That the parts of the drop do suffer a twofold contraction.

Thirdly, That the dropping or quenching the glowing metal in the Water makes it of a hard, fpringing, and rarified texture.

Fourthly, That there is a flexion or force remaining upon the parts of the Glass thus quenched, from which they indeavour to extricate themselves.

Fifthly, That the Fabrick of the drop, that is able to hinder the parts from extricating themselves, is analogus to that of an Arch.

Sixthly, That the fudden flying afunder of the parts proceeds from their fpringiness.

Seventhly, That a gradual heating and cooling does anneal or reduce the parts of Glassto a texture that is more loose, and easilier to be broken, but not so brittle.

That the first of these is true may be gathered from this, That Heat is a property of a body arising from the motion or agitation of its parts; and therefore whatever body is thereby toucht must necessarily receive some part of that motion, whereby its parts will be shaken and agitated, and so by degrees free and extricate themfelves from one another, and each part fo moved does by that motion exert a conatus of protruding and difplacing all the adjacent Particles. Thus Air included in a vefiel, by being heated will burft it to pieces. Thus have I broke a Bladder held over the fire in my hand, with fuch a violence and noife, that it almost made me deaf for the prefent, and much furpafied the noise of a Musket: The like have I done by throwing into the fire fmall glass Bubbles hermetically fealed, with a little drop of Water included in them. Thus Water allo, or any other Liquor, included in a convenient veficl, by being warmed, manifeftly expands it felf with a very great violence, fo as to break the ftrongest vessel, if when heated it be narrowly imprisoned in it. This

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This is very manifest by the fealed Thermometers, which I have, by feveral tryals, at last brought to a great certainty and tenderness : for I have made fome with stems above four foot long, in which the expanding Liquor would fo far vary, as to be very neer the very top in the heat of Summer, and prety neer the bottom at the coldeft time of the Winter. The Stems I use for them are very thick, straight, and even Pipes of Glass, with a very small perforation, and both the head and body I have made on purpose at the Glass-house, of the same metal whereof the Pipes are drawn: thefe I can eafily in the flame of a Lamp, urged with the blaft of a pair of Bellows, feal and clofe together, fo as to remain very firm, clofe and even; by this means I joyn on the body first, and then fill both it and a part of the stem, proportionate to the length of the stem and the warmth of the feafon I fill it in, with the beft rectified spirit of Wine highly ting'd with the lovely colour of Cocheneel, which I deepen the more by pouring fome drops of common spirit of Urine, which must not be too well rectified, becaufe it will be apt to make the Liquor to curdle and stick in the small perforation of the stem. This Liquor I have upon tryal found the most tender of any spirituous Liquor, and those are much more fenfibly affected with the variations of heat and cold then other more flegmatick and ponderous Liquors, and as capable of receiving a deep tincture, and keeping it, as any Liquor whatfoever; and (which makes it yet more acceptable) is not subject to be frozen by any cold yet known. When I have thus filled it, I can very eafily in the forementioned flame of a Lamp feal and joyn on the head of it.

Then, for graduating the stem, I fix that for the beginning of my division where the furface of the liquor in the ftem remains when the ball is placed in common diffilled water, that is fo cold that it just begins to freeze and fhoot into flakes; and that mark I fix at a convenient place of the stem, to make it capable of exhibiting very many degrees of cold, below that which is requisite to freeze water: the rest of my divisions, both above and below this (which I mark with a [0] or nought) I place according to the Degrees of Expansion, or Contraction of the Liquor in proportion to the bulk it had when it indur'd the newly mention'd freezing cold. And this may be very eafily and accurately enough done by this following way; Prepare a Cylindrical vefiel of very thin plate Brafs or Silver, A B C D of the figure Z; the Diameter A B of whofe cavity let be about two inches, and the depth B C the fame; let each end be cover'd with a flat and fmooth plate of the fame fubftance, closely foder'd on, and in the midft of the upper cover make a pretty large hole E F, about the bigness of a fifth part of the Diameter of the other; into this falten very well with cement a straight and even Cylindrical pipe of Glass, EFGH, the Diameter of whofe cavity let be exactly one tenth of the Diameter of the greater Cylinder. Let this pipe be mark'd at GH with a Diamant, fo that G from E may be diftant just two inches, or the fame height with that of the cavity of the greater Cylinder, then divide the length E G exactly into 10 parts, fo the capacity of the hollow of each of these divisions will be i part of the capacity of the greater Cylinder.

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der. This veffel being thus prepared, the way of marking and graduating the *Thermometers* may be very eafily thus performed :

Fill this Cylindrical veffel with the fame liquor wherewith the Thermometers are fill'd, then place both it and the Thermometer you are to graduate, in water that is ready to be frozen, and bring the furface of the liquor in the Thermometer to the firft marke or [o]; then fo proportion the liquor in the Cylindrical veffel, that the furface of it may juft be at the lower end of the fmall glafs-Cylinder; then very gently and gradually warm the water in which both the Thermometer and this Cylindrical veffel ftand, and as you perceive the ting'd liquor to rife in both ftems, with the point of a Diamond give feveral marks on the ftem of the Thermometer at those places, which by comparing the expansion in both Stems, are found to correspond to the divisions of the cylindrical veffel, and having by this means marked fome few of these divisions on the Stem, it will be very easile by these to mark all the rest of the Stem, and accordingly to assign to every division a proper character.

A Thermometer, thus marked and prepared, will be the fitteft Inftrument to make a Standard of heat and cold that can be imagined. For being fealed up, it is not at all subject to variation or wasting, nor is it liable to be changed by the varying preffure of the Air, which all other kind of Thermometers that are open to the Air are liable to. But to proceed.

This property of Expansion with Heat, and Contraction with Cold, is not peculiar to Liquors only, but to all kind of folid Bodies also, especially Metals, which will more manifestly appear by this Experiment.

Take the Barrel of a Stopcock of Braß, and let the Key, which is well fitted to it, be riveted into it, fo that it may flip, and be eafily turned round, then heat this Cock in the fire, and you will find the Key fo fwollen, that you will not be able to turn it round in the Barrel ; but if it be fuffered to cool again, as foon as it is cold it will be as movable, and as eafie to be turned as before.

This Quality is allo very observable in Lead, Tin, Silver, Antimony, Pitch, Rofin, Bees-wax, Butter, and the like; all which, if after they be melted you fuffer gently to cool, you shall find the parts of the upper Surface to fubfide and fall inwards, lofing that plumpness and smoothness it had whilst in fusion. The like I have also observed in the cooling of Glass of Antimony, which does very neer approach the nature of Glafs, But because these are all Examples taken from other materials then Glafs, and argue only, that poffibly there may be the like property alfo in Glass, not that really there is ; we shall by three or four Experiments indeavour to manifest that also. And the First is an Observation that is very obvious even in these very drops, to wit, that they are all of them terminated with an unequal or irregular Surface, especially about the smaller part of the drop, and the whole length of the ftem; as about D, and from thence to A, the whole Surface, which would have been round if the drop had cool'd leifurely, is, by being quenched haftily, very irregularly flatted and pitted ; which

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I suppose proceeds partly from the Waters unequally cooling and preffing the parts of the drop, and partly from the felf-contracting or subsiding quality of the substance of the Glass: For the vehemency of the heat of the drop causes such sudden motions and bubbles in the cold Water, that some parts of the Water bear more forcibly against one part then against another, and consequently do more suddenly cool those parts to which they are contiguous.

A Second Argument may be drawn from the Experiment of cutting Glaffes with a hot Iron. For in that Experiment the top of the Iron heats, and thereby rarifies the parts of the Glafs that lie just before the crack, whence each of those agitated parts indeavouring to expand its felf and get elbow-room, thrusts off all the rest of the contiguous parts, and consequently promotes the crack that was before begun.

A Third Argument may be drawn from the way of producing a crack in a found piece or plate of Glafs, which is done two wayes, either First, by fuddenly heating a piece of Glass in one place more then in another. And by this means Chymists usually cut off the necks of Glass-bodies, by two kinds of Instruments, either by a glowing hot round Iron-Ring, which just incompasses the place that is to be cut, or elfe by a sulphur'd Threed, which is often wound about the place where the feparation is to be made, and then fired. Or Secondly, A Glafs may be cracked by cooling it fuddenly in any place with Water, or the like, after it has been all leifurely and gradually heated very hot. Both which Phanomena feem manifestly to proceed from the expansion and contraction of the parts of the Glafs, which is also made more probable by this circumstance which I have observed, that a piece of common window-glass being heated in the middle very fuddenly with a live Coal or hot Iron, does ufually at the first crack fall into pieces, whereas if the Plate has been gradually heated very hot, and a drop of cold Water and the like be put on the middle of it, it only flaws it, but does not break it asunder immediately.

A Fourth Argument may be drawn from this Experiment; Take a Glass-pipe, and fit into it a folid stick of Glass, so as it will but just be moved in it. Then by degrees heat them whilft they are one within another, and they will grow stiffer, but when they are again cold, they will be as easie to be turned as before. This Expansion of Glass is more manifeft in this Experiment. Take a stick of Glass of a confiderable length, and fit it so between the two ends or fcrews of a Lath, that it may but just eafily turn, and that the very ends of it may be just toucht and sufferned thereby; then applying the flame of the Candle to the middle of it, and heating it hot, you will prefently find the Glafs to flick very fast on those points, and not without much difficulty to be convertible on them, before that by removing the flame for a while from it, it be fuffered to cool, and en you will find it as easie to be turned round as at the first. From all which Experiments it is very evident, that all those Bodies, and particularly Glafs, fuffers an Expansion by Heat, and that a very confiderable

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fiderable one, whilst they are in a state of Fusion. For Fluidity, as I elsewhere mention, being nothing but an effect of a very strong and quick shaking motion, whereby the parts are, as it were, loofened from each other, and confequently leave an interjacent space or vacuity; it follows, that all those shaken Particles must neceffarily take up much more room then when they were at reft, and lay quietly upon each other. And this is further confirmed by a Pot of boyling Alabaster, which will manifestly rife a fixth or eighth part higher in the Pot, whilst it is boyling, then it will remain at, both before and after it be boyled. The reason of which odd Phanomenon (to hint it here only by the way) is this, that there is in the curious powder of Alabaster, and other calcining Stones, a certain watery fubstance, which is fo fixt and included with the folid Particles, that till the heat be very confiderable they will not fly away; but after the heat is increased to such a degree, they break out every way in vapours, and thereby fo shake and loofen the small corpusses of the Powder from each other, that they become perfectly of the nature of a fluid body, and one may move a flick to and fro through it, and flir it as eafily as water, and the vapours burft and break out in bubbles juft as in boyling water, and the like; whereas, both before those watery parts are flying away, and after they are quite gone; that is, before and after it have done boyling, all those effects cease, and a stick is as difficultly moved to and fro in it as in fand, or the like. Which Explication I could eafily prove, had I time; but this is not a fit place for it.

To proceed therefore, I fay, that the dropping of this expanded Body into cold Water, does make the parts of the Glass suffer a double contraction : The first is, of those parts which are neer the Surface of the Drop. For Cold, as I faid before, contracting Bodies, that is, by the abatement of the agitating faculty the parts falling neerer together; the parts next adjoying to the Water must needs lose much of their motion, and impart it to the Ambient-water (which the Ebullition and commotion of it manifests) and thereby become a folid and hard cruft, whilft the innermost parts remain yet fluid and expanded ; whence, as they grow cold alfo by degrees, their parts must necessar rily be left at liberty to be condenfed, but becaufe of the hardness of the outward cruft, the contraction cannot be admitted that way; but there being many very fmall, and before inconfpicuous, bubbles in the fubstance of the Glass, upon the fubliding of the parts of the Glass, the agil fubftance contained in them has liberty of expanding it felf a little, and thereby those bubbles grow much bigger, which is the fecond Contraction. And both thefe are confirmed from the appearance of the Drop it felf: for as for the outward parts, we fee, first, that it is irregular and shrunk, as it were, which is caused by the yielding a little of the hardened Skin to a Contraction, after the very outmost Surface is settled; and as for the internal parts, one may with ones naked Eye perceive abundance of very confpicuous bubbles, and with the Microscope many more. The Confideration of which Particulars will eafily make the Third Polition probable, that is, that the parts of the drop will be of a very hard, though of a rarified Texture; for if the outward parts of the Drop, by realon of its hard cruft, will indure very little Contraction, and the agil Particles, included

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ded in those bubbles, by the losing of their agitation, by the decrease of the Heat, lose also most part of their Spring and Expansive power; it follows (the withdrawing of the heat being very fudden) that the parts must be left in a very loose Texture, and by reason of the implication of the parts one about another, which from their fluggishnes and glutinous field to be much after the manner of the sticks in a Thorn-bush, or a Lock of Wool; It will follow, I fay, that the parts will hold each other very strongly together, and indeavour to draw each other neerer together, and consequently their Texture must be very hard and stiff, but very much rarified.

And this will make probable my next Pofition, That the parts of the Glafs are under a kind of tenfion or flexure,out of which they indeavour to extricate and free themfelves, and thereby all the parts draw towards the Center or middle, and would, if the outward parts would give way, as they do when the outward parts cool leifurely (as in baking of Glaffes) contract the bulk of the drop into a much lefs compafs. For fince, as I proved before, the Internal parts of the drop, when fluid, were of a very rarified Texture, and, as it were, tos'd open like a Lock of Wool, and if they were fuffered leifurely to cool, would be again preft, as it were, clofe together: And fince that the heat, which kept them bended and open, is removed, and yet the parts not fuffered to get as neer together as they naturally would; It follows, that the Particles remain under a kind of *tenfion* and *flexure*, and confequently have an indeavour to free themfelves from that *bending* and *diftenfion*, which they do, as foon as either the tip be broken, or as foon as by a leifurely heating and cooling, the parts are nealed into another pofture.

And this will make my next Polition probable, that the parts of the Glass drops are contignated together in the form of an Arch, and cannot any where yield or be drawn inwards, till by the removing of fome one part of it (as it happens in the removing one of the ftones of an Arch) the whole Fabrick is fhatter'd, and falls to pieces, and each of the Springs is left at liberty, fuddenly to extricate it felf: for fince I have made it probable, that the internal parts of the Glafs have a contractive power inwards, and the external parts are incapable of fuch a Contraction, and the figure of it being spherical; it follows, that the superficial parts must bear against each other, and keep one another from being condens'd into a lefs room, in the fame manner as the frones of an Arch conduce to the upholding each other in that Figure. And this is made more probable by another Experiment which was communicated to me by an excellent Perfon, whofe extraordinary Abilities in all kind of Knowledg, efpecially in that of Natural things, and his generous Disposition in communicating, incouraged me to have recourfe to him on many occasions. The Experiment was this : Small Glass-balls (about the bigness of that represented in the Figure O.) would, upon rubbing or fcratching the inward Surface, fly all infunder, with a pretty brisk noife; whereas neither before nor after the inner Surface had been thus scratcht, did there appear any flaw or crack. And putting the pieces of one of those broken ones together again, the flaws appeared much after the manner of the black lines on the Figure, O. These Balls were small, but exceeding thick bubbles of Glass, which being crack'd off from the Puntilion whilft very hot, and fo fuffered to cool without nealing them in the

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the Oven over the Furnace, do thereby (being made of white Glafs, which cools much quicker then green Glafs, and is thereby made much brittler) acquire a very porous and very brittle texture: fo that if with the point of a Needle or Bodkin, the infide of any of them be rubbed prety hard, and then laid on a Table, it will, within a very little while, break into many pieces with a brisk noife, and throw the parts above a fpan alunder on the Table: Now though the pieces are not fo fmall as those of a fulminating drop, yet they as plainly flow, that the outward parts of the Glafs have a great Conatus to fly alunder, were they not held together by the tenacity of the parts of the inward Surface : for we fee as 100n as those parts are crazed by hard rubbing, and thereby their tenacity so the foring iness of the more outward parts quickly makes a divulfion, and the broken pieces will, if the concave Surface of them be further feratcht with a Diamond, fly again into fmaller pieces.

From which preceding confiderations it will follow Sixthly, That the fudden flying afunder of the parts as foon as this Arch is any where difordered or broken, proceeds from the springing of the parts; which, indeavouring to extricate themfelves as foon as they get the liberty, they perform it with fuch a quickness, that they throw one another away with very great violence: for the Particles that compose the Crust have a Conatus to lye further from one another, and therefore as foon as the external parts are loofened they dart themfelves outward with great violence, just as fo many Springs would do, if they were detained and fastened to the body, as foon as they should be fuddenly loofened; and the internal parts drawing inward, they contract fo violently, that they rebound back again and fly into multitude of fmall fhivers or fands. Now though they appear not, either to the naked Eye, or the Microscope, yet I am very apt to think there may be abundance of small flaws or cracks, which, by reason the strong reflecting Air is not got between the contiguous parts, appear not. And that this may be fo, I argue from this, that I have very often been able to make a crack or flaw, in some convenient pieces of Glass, to appear and disappear at pleasure, according as by preffing together, or pulling afunder the contiguous parts, I excluded or admitted the ftrong reflecting Air between the parts: And it is very probable, that there may be fome Body, that is either very rarified Air, or fomething analogous to it, which fills the bubbles of these drops; which I argue, first, from the roundnefs of them, and next, from the vivid reflection of Light which they exhibite : Now though I doubt not, but that the Air in them is very much rarified, yet that there is fome in them, to fuch as well confider this Experiment of the disappearing of a crack upon the extruding of the Air, I fuppose it will feem more then probable. The Seventh and last therefore that I shall prove, is, That the gradual heating and cooling of these so extended bodies dues reduce the parts of the Glass to a loofer and fofter temper. And this I found by heating them, and keeping them for a prety while very red hot in a fire; for thereby I found them to grow a little lighter, and the small Stems to be very easily broken and inapt any where, without at all making the drop fly; whereas before H 2

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before they were fo exceeding hard, that they could not be broken without much difficulty; and upon their breaking the whole drop would fly in pieces with very great violence. The Reafon of which last feems to be, that the leifurely heating and cooling of the parts does not only wast some part of the Glassit self, but ranges all the parts into a better order, and gives each Particle an opportunity of relaxing its felf, and confequently neither will the parts hold fo ftrongly together as before, nor be fo difficult to be broken : The parts now more eafily yielding, nor will the other parts fly in pieces, becaufe the parts have no bended Springs. The relaxation also in the temper of hardned Steel, and hammered Metals, by nealing them in the fire, feems to proceed from much the fame caufe. For both by quenching fuddenly fuch Metals as have vitrid parts interspers'd, as Steel has, and by hammering of other kinds that do not fo much abound with them, as Silver, Brafs, O.c. the parts are put into and detained in a bended posture, which by the agitation of Heat are shaken, and loofened, and suffered to unbend themselves.

Observ. VIII. Of the fiery Sparks struck from a Flint or Steel.

sebens. 5.] T is a very common Experiment, by striking with a Flint against a Steel, to make certain fiery and shining Sparks to fly out from between those two compressing Bodies. About eight years fince, upon cafually reading the Explication of this odd Phanomenon, by the most Ingenious Des Cartes, I had a great defire to be fatisfied, what that Substance was that gave fuch a fhining and bright Light : And to that end I fpread a fheet of white Paper, and on it, observing the place where several of these Sparks feemed to vanish, I found certain very small, black, but glistering Spots of a movable Substance, each of which examining with my Miscrocope, I found to be a fmall round Globule ; fome of which, as they looked prety small, fo did they from their Surface yield a very bright and strong reflection on that fide which was next the Light; and each look'd almost like a prety bright Iron-Ball, whole Surface was prety regular, fuch as is represented by the Figure A. In this I could perceive the Image of the Window prety well, or of a Stick, which I moved up and down between the Light and it. Others I found, which were, as to the bulk of the Ball, prety regularly round, but the Surface of them, as it was not very fmooth, but rough, and more irregular, fo was the reflection from it more faint and confused. Such were the Surfaces of B. C. D. and E. Some of these I found cleft or cracked, as C, others quite broken in two and hollow, as D. which feemed to be half the hollow shell of a Granado, broken irregularly in pieces. Several others I found of other shapes; but that which is represented by E, I observed to be a very big Spark of Fire, which went out upon one fide of the Flint that I ftruck fire withall, to which

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which it fluck by the root F, at the end of which finall Stem was fastened-on a *Hemisphere*, or half a hollow Ball, with the mouth of it open from the stemwards, so that it looked much like a Funnel, or an old fashioned Bowl without a foot. This night, making many tryals and observations of this Experiment, I met, among a multitude of the Globular ones which I had observed, a couple of Instances, which are very remarkable to the confirmation of my *Hypothesis*.

And the First was of a pretty big Ball fastened on to the end of a small fliver of Iron, which *Compositum* seemed to be nothing else but a long thin chip of Iron, one of whose ends was melted into a small round Globul; the other end remaining unmelted and irregular, and perfectly Iron.

The Second Inftance was not lefs remarkable then the Firft; for 1 found, when a Spark went out, nothing but a very fmall thin long fliver of Iron or Steel, unmelted at either end. So that it feems, that fome of thefe Sparks are the flivers or chips of the Iron *vitrified*, Others are only the flivers melted into Balls without vitrification, And the third kind are only fmall flivers of the Iron, made red-hot with the violence of the ftroke given on the Steel by the Flint.

He that shall diligently examine the Phanomena of this Experiment, will, I doubt not, find caufe to believe, that the reafon I have heretofore given of it, is the true and genuine caufe of it, namely, That the Spark appearing so bright in the falling is nothing else but a small piece of the Steel or Flint, but most commonly of the Steel, which by the violence of the stroke is at the same time sever'd and heatt red-hot, and that sometimes to such a degree, as to make it melt together into a small Globule of Steel; and sometimes also is that heat so very intense, as further to melt it and vitrifie it; but many times the heat is so gentle, as to be able to make the fliver only red hot; which notwithstanding falling upon the tinder (that is only a very curious fmall Coal made of the fmall threads of Linnen burnt to coals and char'd) it easily sets it on fire. Nor will any part of this Hypothesis seemi strange to him that confiders, First, that either hammering, or filing, or otherwife violently rubbing of Steel, will prefently make it fo hot as to be able to burn ones fingers. Next, that the whole force of the stroke is exerted upon that fmall part where the Flint and Steel first touch: For the Bodies being each of them fo very hard, the puls cannot be far communicated, that is, the parts of each can yield but very little, and therefore the violence of the concuffion will be exerted on that piece of Steel which is cut off by the Flint. Thirdly, that the filings or fmall parts of Steel are very apt, as it were, to take fire, and are prefently red hot, that is, there seems to be a very combustible sulphureous Body in Iron or Steel, which the Air very readily preys upon, as foon as the body is a little violently heated. And this is obvious in the filings of Steel or Iron caft through the flame of a Candle ; for even by that fudden transitus of the small chips of Iron, they are heat red hot, and that combustible sulphureous Body is presently prey'd upon and devoured by the aereal incompassing Menstruum, whole office in this Particular I have fhewn in the Explication of Charcole. And

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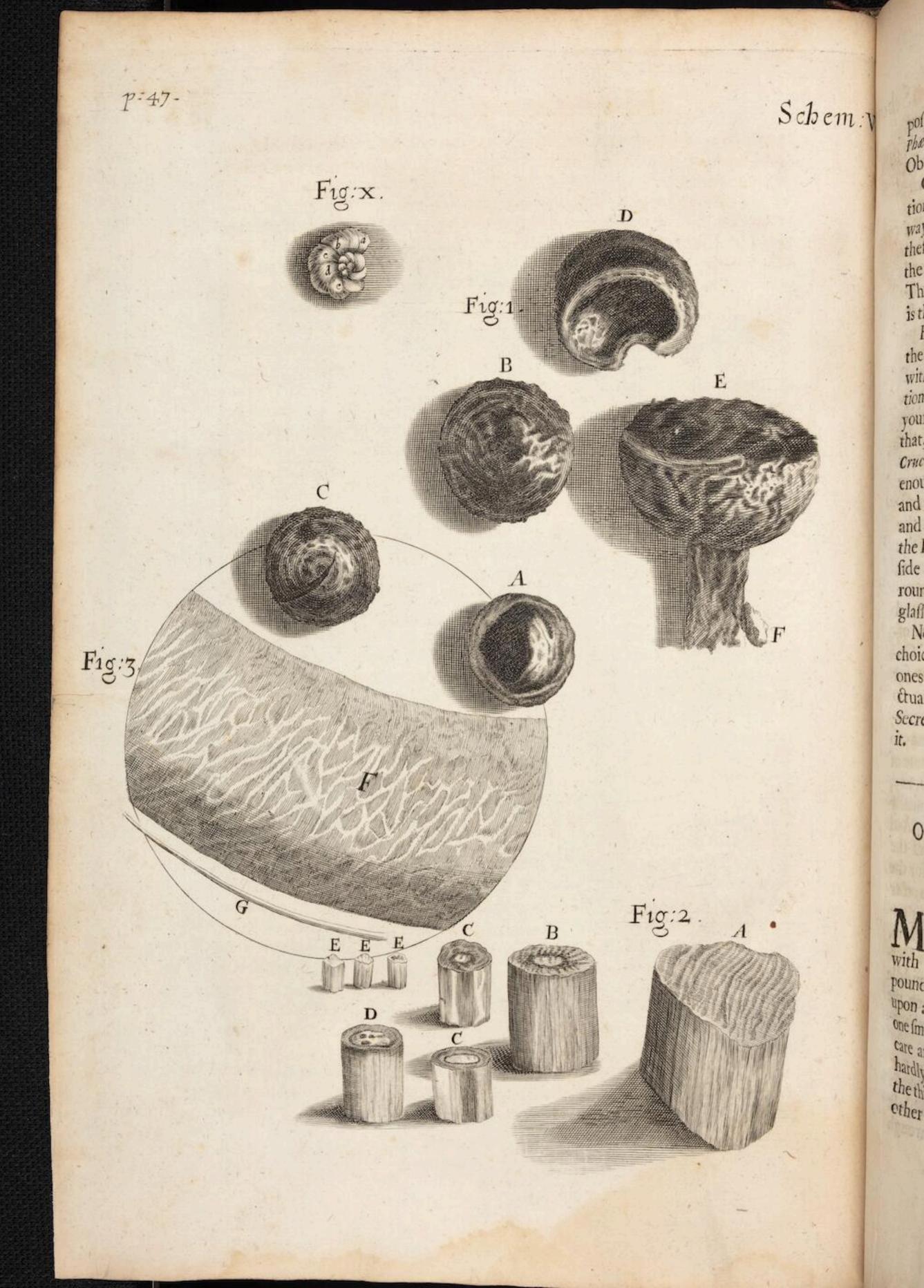
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And in profecution of this Experiment, having taken the filings of Iron and Steel, and with the point of a Knife caft them through the flame of a Candle, I obferved where fome confpicuous fhining Particles fell, and looking on them with my *Microfcope*, I found them to be nothing elfe but fuch round Globules, as I formerly found the Sparks ftruck from the Steel by a ftroke to be, only a little bigger; and flaking together all the filings that had fallen upon the fheet of Paper underneath, and obferving them with the *Microfcope*, I found a great number of fmall Globules, fuch as the former, though there were alfo many of the parts that had remained untoucht, and rough filings or chips of Iron. So that, it feems, Iron does contain a very *combuftible fulphureous* Body, which is, in all likelihood, one of the caufes of this *Phænomenon*, and which may be perhaps very much concerned in the bufinefs of its hardening and tempering : of which fomewhat is faid in the Defcription of *Mufcovy-glafs*.

So that, these things confidered, we need not trouble our felves to find out what kind of Pores they are, both in the Flint and Steel, that contain the Atoms of fire, nor how those Atoms come to be hindred from running all out, when a dore or passage in their Pores is made by the concuffion: nor need we trouble our selves to examine by what Prometheus the Element of Fire comes to be fetcht down from above the Regions of the Air, in what Cells or Boxes it is kept, and what Epimetheus lets it go : Nor to confider what it is that caufes fo great a conflux of the atomical Particles of Fire, which are faid to fly to a flaming Body, like Vultures or Eagles to a putrifying Carcafs, and there to make a very great pudder. Since we have nothing more difficult in this Hypothesis to conceive, first, as to the kindling of Tinder, then how a large Iron-bullet, let fall red or glowing hot upon a heap of Small-coal, should fet fire to those that are next to it first : Nor secondly, is this last more difficult to be explicated, then that a Body, as Silver for Instance, put into a weak Menstruum, as unrectified Aqua fortis should, when it is put in a great heat, be there diffolved by it, and not before; which Hypothesis is more largely explicated in the Description of Charcoal. To conclude, we see by this Instance, how much Experiments may conduce to the regulating of Philosophical notions. For if the most Acute Des Cartes had applied himself experimentally to have examined what fubftance it was that caufed that shining of the falling Sparks struck from a Flint and a Steel, he would certainly have a little altered his Hypothesis, and we should have found, that his Ingenious Principles would have admitted a very plaufible Explication of this Phanomenon; whereas by not examining fo far as he might, he has fet down an Explication which Experiment do's contradict. But before I leave this Description, I must not forget to take notice of the Globular form into which each of these is most curiously formed. And this Phanomenon, as I have elfewhere more largely fhewn, proceeds from a propriety which belongs to all kinds of fluid Bodies more or lefs, and is caufed by the Incongruity of the Ambient and included Fluid, which fo acts and modulates each other, that they acquire, as neer as is poffible,

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poffible, a sperical or globular form, which propriety and feveral of the Phanomena that proceed from it, I have more fully explicated in the fixth Obfervation. lyr. In many Places they out

One Experiment, which does very much illustrate my present Explication, and is in it felf exceeding pretty, I must not passby: And that is a way of making small Globules or Balls of Lead, or Tin, as small almost as thefe of Iron or Steel, and that exceeding eafily and quickly, by turning the filings or chips of those Metals also into perfectly round Globules. The way, in fhort, as I received it from the Learned Phylitian Doctor I.G. is this;

Reduce the Metal you would thus shape, into exceeding fine filings, the finer the filings are, the finer will the Balls be: Stratifie thefe filings with the fine and well dryed powder of quick Lime in a Crucible proportioned to the quantity you intend to make : When you have thus filled your Crucible, by continual stratifications of the filings and powder, fo that, as neer as may be, no one of the filings may touch another, place the Crucible in a gradual fire, and by degrees let it be brought to a heat big enough to make all the filings, that are mixt with the quick Lime, to melt, and no more; for if the fire be too hot, many of these filings will joyn and run together; whereas if the heat be proportioned, upon washing the Lime-duft in fair Water, all those small filings of the Metal will subfide to the bottom in a most curious powder, confisting all of exactly round Globules, which, if it be very fine, is very excellent to make Hourglaffes of.

Now though quick Lime be the powder that this direction makes choice of, yet I doubt not, but that there may be much more convenient ones found out, one of which I have made tryal of, and found very effectual; and were it not for discovering, by the mentioning of it, another Secret, which I am not free to impart, I fhould have here inferted it.

Observ. IX. Of the Colours observable in Muscovy Glass, and other thin Bodies.

pioli parts all of one colour , which we

MOfcovy-glafs, or Lapis specularis, is a Body that feems to have as ma-ny Curiofities in its Fabrick as any common Mineral I have met with : for first, It is transparent to a great thickness : Next, it is compounded of an infinite number of thin flakes joyned or generated one upon another fo clofe & fmooth, as with many hundreds of them to make one mooth and thin Plate of a transparent flexible fubstance, which with care and diligence may be flit into pieces fo exceedingly thin as to be hardly perceivable by the eye, and yet even those, which I have thought the thinnest, I have with a good Microscope found to be made up of many other Plates, yet thinner; and it is probable, that, were our Microscopes much

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much better, we might much further discover its divisibility. Nor are these flakes only regular as to the imoothness of their Surfaces; but thirdly, In many Plates they may be perceived to be terminated naturally with edges of the figure of a Rhomboeid. This Figure is much more conspicuous in our English talk, much whereof is found in the Lead Mines, and is commonly called spar, and Kauck, which is of the fame kind of fubstance with the sclenitis, but is feldom found in fo large flakes as that is, nor is it altogether fo tuff, but is much more clear and transparent, and much more curioufly shaped, and yet may be cleft and flak'd like the other selenitis. But fourthly, this frome has a property, which in respect of the Microscope, is more notable, and that is, that it exhibits feveral appearances of Colours, both to the naked Eye, but much more confpicuoutly to the Microscope; for the exhibiting of which, I took a piece of Muscovy-glass, and splitting or cleaving it into thin Plates, I found that up , and down in feveral parts of them I could plainly perceive feveral white fpecks or flaws, and others diverfly coloured with all the Colours of the Rainbow; and with the Microscope I could perceive, that these Colours were ranged in rings that incompassed the white speck or flaw, and were round or irregular, according to the fhape of the fpot which they terminated ; and the polition of Colours, in respect of one another, was the very fame as in the Rainbow. The confecution of those Colours from the middle of the fpot outward being Blew, Purple, Scarlet, Yellow, Green; Blew, Purple, Scarlet, and fo onwards, fometimes half a fcore times repeated, that is, there appeared fix, feven, eight, nine or ten feveral coloured rings or lines, each incircling the other, in the fame manner as I have often seen a very vivid Rainbow to have four or five several Rings of Colours, that is, accounting all the Gradations between Red and Blew for one : But the order of the Colours in these Rings was quite contrary to the primary or innermost Rainbow, and the fame with those of the fecondary or outermost Rainbow; these coloured Lines or Irifes, as I may fo call them, were fome of them much brighter then others, and fome of them also very much broader, they being some of them ten, twenty, nay, Ibelieve, neer a hundred times broader then others; and those usually were broadish which were neerest the center or middle of the flaw. And oftentimes I found, that these Colours reacht to the very middle of the flaw, and then there appeared in the middle a very large fpot, for the most part, all of one colour, which was very vivid, and all the other Colours incompating it, gradually afcending, and growing narrower towards the edges, keeping the fame order, as in the fecundary Rainbow, that is, if the middle were Blew, the next incompassing it would be a Purple, the third a Red, the fourth a Yellow, O.c. as above ; if the middle were a Red, the next without it would be a Yellow, the third a Green, the fourth a Blew, and fo onward,. And this order it alwayes kept what foever were the middle Colour. There was further observable in several other parts of this Body, many Lines or Threads, each of them of some one peculiar Colour, and those to exceedingly bright and vivid, that it afforded a very pleafant object through

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through the Microfcope. Some of these threads I have observed alfo to be pieced or made up of feveral fhort lengths of differently coloured ends (as I may fo call them) as a line appearing about two inches long through the Microscope, has been compounded of about half an inch of a Peach colour, # of a lovely Grafs-green, # of an inch more of a bright Scarlet, and the reft of the line of a Watchet blew. Others of them were much otherwife coloured; the variety being almost infinite. Another thing which is very observable, is, that if you find any place where the colours are very broad and confpicuous to the naked eye, you may, by preffing that place with your finger, make the colours change places, and go from one part to another.

There is one Phanomenon more, which may, if care be used, exhibit to the beholder, as it has divers times to me, an exceeding pleafant, and not less instructive Spectacle; And that is, if curiofity and diligence be used, you may fo split this admirable Substance, that you may have pretty large Plates (in comparison of those smaller ones which you may observe in the Rings) that are perhaps an 1 or a 2 part of an inch over each of them appearing through the Microfcope most curiously, intirely, and uniformly adorned with fome one vivid colour : this, if examined with the Microscope, may be plainly perceived to be in all parts of it equally thick. Two, three, or more of these lying one upon another, exhibit oftentimes curious compounded colours, which produce fuch a Compositum, as one would scarce imagine should be the refult of such ingredients: As perhaps a faint yellow and a blew may produce a very deep purple. But when a non we come to the more ftrict examination of these Phanomena, and to inquire into the caufes and reasons of these productions, we shall, I hope, make it more conceivable how they are produced, and shew them to be no other then the natural and necessary effects arifing from the peculiar union of concurrent caufes.

These Phanomena being so various, and fo truly admirable, it will certainly be very well worth our inquiry, to examine the caufes and reafons of them, and to confider, whether from these causes demonstratively evidenced, may not be deduced the true causes of the production of all kind of Colours. And I the rather now do it, inftead of an Appendix or Digreffion to this Hiftory, then upon the occasion of examining the Colours in Peacocks, or other Feathers, because this Subject, as it does afford more variety of particular Colours, fo does it afford much better wayes of examining each circumstance. And this will be made manifest to him that confiders, first, that this laminated body is more fimple and regular then the parts of Peacocks feathers, this confifting only of an indefinite number of plain and fmooth Plates, heaped up, or incumbent on each other. Next, that the parts of this body are much more manageable, to be divided or joyned, then the parts of a Peacocks feather, or any other substance that I know. And thirdly, because that in this we are able from a colourless body to produce several coloured bodies, affording all the variety of Colours imaginable : And feveral others, which the subsequent Inquiry will make manifest. Te

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To begin therefore, it is manifest from several circumstances, that the material cause of the *apparition* of these several Colours, is some Lamina or Plate of a transparent or pellucid body of a thickness very determinate and proportioned according to the greater or less refractive power of the *pellucid* body. And that this is so abundance of Instances and particular Circumstances will make manifest.

As first, if you take any small piece of the *Muscovy-glass*, and with a Needle, or some other convenient Instrument, cleave it oftentimes into thinner and thinner *Laminæ*, you shall find, that till you come to a determinate thinners of them, they shall all appear transparent and colourless, but if you continue to split and divide them further, you shall find at last, that each Plate, after it comes to such a determinate thickness, shall appear most lovely ting'd or imbued with a determinate colour. If *further*, by any means you so the other, and between those two there be by any means gotten fome pellucid *medium*, those *laminated* pellucid bodies that fill that space, so that lexibilit feveral Rainbows or coloured Lines, the colours of which will be disposed and ranged according to the various thickness of the feveral parts of that Plate. That this is so, is yet *further* ther confirmed by this Experiment.

Take two small pieces of ground and polisht Looking-glass-plate, each about the bigness of a shilling, take these two dry, and with your fore-fingers and thumbs prefs them very hard and clofe together, and you shall find, that when they approach each other very near, there will appear feveral Irifes or coloured Lines, in the fame manner almost as in the Muscovy-glass; and you may very eafily change any of the Colours of any part of the interposed body, by preffing the Plates closer and harder together, or leaving them more lax; that is, a part which appeared coloured with a red, may be prefently ting'd with a yellow, blew, green, purple, or the like, by altering the appropinquation of the terminating Plates. Now that air is not necessary to be the interposed body, but that any other transparent fluid will do much the fame, may be tryed by wetting those approximated Surfaces with Water, or any other transparent Liquor, and proceeding with it in the fame manner as you did with the Air; and you will find much the like effect, only with this difference, that those comprest bodies, which differ most, in their refractive quality, from the compreffing bodies, exhibit the most strong and vivid tin-Etures. Nor is it neceffary, that this laminated and ting'd body fhould be of a fluid fubstance, any other fubstance, provided it be thin enough and transparent, doing the fame thing : this the Lamine of our Muscovyglass hint; but it may be confirm'd by multitudes of other Instances. And first, we shall find, that even Glass it self may, by the help of a Lamp, be blown thin enough to produce these Phanomena of Colours: which Phanomena accidentally happening, as I have been attempting to frame fmall Glasses with a Lamp, did not a little surprize me at first, having never heard or seen any thing of it before ; though afterwards comparing it with the Phanomena, I had often observed

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observed in those Bubbles which Children use to make with Soap-water, I did the less wonder ; especially when upon Experiment I found, I was able to produce the same *Phænomena* in thin Bubbles made with any other transparent Substance. Thus have I produced them with Bubbles of *Pitch*, *Rosin*, *Colophony*, *Turpentine*, *Solutions* of several *Gums*, as *Gum-Arabick* in water; any glutinous Liquor, as Wort, Wine, Spirit of Wine, Oyl of Turpentine, Glare of Snails, &c.

It would be needless to enumerate the feveral Inftances, these being enough to shew the generality or universality of this propriety. Only I must not omit, that we have inftances also of this kind even in metalline Bodies and animal; for those feveral Colours which are observed to follow each other upon the polisht furface of hardned Steel, when it is by a fufficient degree of heat gradually tempered or softened, are produced from nothing else but a certain thin *Lamina* of a *vitrum* or *vitrified* part of the Metal, which by that degree of heat, and the concurring action of the ambient Air, is driven out and fixed on the furface of the Steel.

And this hints to me a very probable (at leaft, if not the true) caufe of the hardning and tempering of Steel, which has not, I think, been yet given, nor, that I know of been fo much as thought of by any. And that is this, that the hardnefs of it arifes from a greater proportion of a vitrified Subftance interfperfed through the pores of the Steel. And that the tempering or foftning of it arifes from the proportionate or finaller parcels of it left within those pores. This will feem the more probable, if we confider these Particulars.

First, That the pure parts of Metals are of themselves very flexible and tuff; that is, will indure bending and hammering, and yet retain their continuity.

Next, That the Parts of all vitrified Substances, as all kinds of Glass, the *Scoria* of Metals, & c. are very hard, and also very brittle, being neither *flexible* nor *malleable*, but may by hammering or beating be broken into fmall parts or powders.

Thirdly, That all Metals (excepting Gold and Silver , which do not fo much with the bare fire, unlefs affifted by other faline Bodies) do more or lefs vitrifie by the ftrength of fire, that is, are corroded by a faline Subftance, which I elfewhere flew to be the true caufe of fire; and are thereby, as by feveral other *Menftruums*, converted into *Scoria*; And this is called, *calciming* of them, by Chimifts. Thus Iron and Copper by heating and quenching do turn all of them by degrees into *Scoria*, which are evidently vitrified Subftances, and unite with Glafs, and are eafily *fufible*; and when cold, very hard, and very brittle.

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of a Cobeen brize ore; often ved Fourthly, That most kind of *Vitrifications* or *Calcinations* are made by Salts, uniting and incorporating with the metalline Particles. Nor do I know any one *calcination* wherein a *Saline* body may not, with very great probability, be faid to be an agent or coadjutor.

Fifthly, That Iron is converted into Steel by means of the incorporation of certain falts, with which it is kept a certain time in the fire.

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Sixthly, That any Iron may, in a very little time, be *cafe hardned*, as the Trades-men call it, by cafing the iron to be hardned with clay, and putting between the clay and iron a good quantity of a mixture of *Orine*, *Soot*, *Sea-falt*, and *Horfes hoofs* (all which contein great quantities of Saline bodies) and then putting the cafe into a good ftrong fire, and keeping it in a confiderable degree of heat for a good while, and afterwards heating, and quenching or cooling it fuddenly in cold water.

Seventhly, That all kind of vitrify'd fubftances, by being fuddenly cool'd, become very hard and brittle. And thence arifes the pretty *Phænomena* of the Glafs Drops, which I have already further explained in its own place.

Eighthly, That those metals which are not so apt to vitrifie, do not acquire any hardness by quenching in water, as Silver, Gold, &c.

These confiderations premis'd, will, I suppose, make way for the more eafie reception of this following Explication of the Phanomena of hardned and temper'd Steel. That Steel is a fubftance made out of Iron, by means of a certain proportionate Vitrification of feveral parts, which are fo curioufly and proportionately mixt with the more tough and unalter'd parts of the Iron, that when by the great heat of the fire this vitrify'd fubftance is melted, and confequently rarify'd, and thereby the pores of the Iron are more open, if then by means of dipping it in cold water it be fuddenly cold, and the parts hardned, that is, stay'd in that fame degree of Expansion they were in when hot, the parts become very hard and brittle, and that upon the fame account almost as small parcels of glass quenched in water grow brittle, which we have already explicated. If after this the piece of Steel be held in fome convenient heat, till by degrees certain colours appear upon the furface of the brightned metal, the very hard and brittle tone of the metal, by degrees relaxes and becomes much more tough and foft; namely, the action of the heat does by degrees loofen the parts of the Steel that were before streached or fet atilt as it were, and stayed open by each other, whereby they become relaxed and fet at liberty, whence fome of the more brittle interjacent parts are thrust out and melted into a thin skin on the furface of the Steel, which from no colour increases to a deep Purple, and so onward by these gradations or confecutions, White, Yellow, Orange, Minium, Scarlet, Furple, Blew, Watchet, &c. and the parts within are more conveniently, and proportionately mixt; and fo they gradually fubfide into a texture which is much better proportion'd and clofer joyn'd, whence that rigidneffe of parts ceases, and the parts begin to acquire their former ductilness. Now, that 'tis nothing but the vitrify'd metal that flicks upon the furface of the colour'd body, is evident from this, that if by any means it be feraped and rubb'd off, the metal underneath it is white and clear; and if it be kept longer in the fire, fo as to increase to a confiderable thickness, it may, by blows, be beaten off in flakes. This is further confirm'd by this observable, that that Iron or Steel will keep longer from rusting which is covered with this vitrify'd cafe : Thus also Lead will, by degrees, be all

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all turn'd into a litharge; for that colour which covers the top being fcum'd or fbov'd afide, appears to be nothing elfe but a litharge or vitrify'd Lead.

This is observable also in some fort, on Brass, Copper, Silver, Gold, Tin, but is most conspicuous in Lead: all those Colours that cover the surface of the Metal being nothing else, but a very thin vitrifi'd part of the heated Metal.

The other Inftance we have, is in Animal bodies, as in Pearls, Mother of Pearl-fhels, Oyfter-fhels, and almoft all other kinds of ftony fhels whatfoever. This have I alfo fometimes with pleafure obferv'd even in Mufcles and Tendons. Further, if you take any glutinous fubftance and run it exceedingly thin upon the furface of a imooth glafs or a polifht metaline body, you fhall find the like effects produced : and in general, wherefoever you meet with a transparent body thin enough, that is terminated by reflecting bodies of differing refractions from it, there will be a production of these pleafing and lovely colours.

Nor is it neceflary, that the two terminating Bodies should be both of the fame kind, as may appear by the vitrified Lamina on Steel, Lead, and other Metals, one surface of which Lamina is contiguous to the surface of the Metal, the other to that of the Air.

Nor is it neceffary, that these colour'd Lamina should be of an even thickness, that is, should have their edges and middles of equal thickness, as in a Looking-glass-plate, which circumstance is only requisite to make the Plate appear all of the same colour; but they may refemble a Lens, that is, have their middles thicker then their edges; or else a double concave, that is, be thinner in the middle then at the edges; in both which cafes there will be various coloured rings or lines, with differing confecutions or orders of Colours; the order of the first from the middle outwards being Red, Yellow, Green, Blew, &c. And the latter quite contrary.

But further, it is altogether neceffary, that the Plate, in the places where the Colours appear, should be of a determinate thickness : First, It must not be more then such a thickness, for when the Plate is increased to fuch a thickness, the Colours cease; and befides, I have seen in a thin piece of Muscovy-glass, where the two ends of two Plates, which appearing both fingle, exhibited two diffiner and differing Colours; but in that place where they were united, and conftituted one double Plate (as I may call it) they appeared transparent and colourless. Nor, Secondly, may the Plates be thinner then fuch a determinate cize; for we alwayes find, that the very outmost Rim of these flaws is terminated in a white and colourless Ring. tinen a the reft; A Further, in this Production of Colours there is no need of a determinate Light of fuch a bigness and no more, nor of a determinate position of that Light, that it fhould be on this fide, and not on that fide; nor of a terminating shadow, as in the Prisme, and Rainbow, or Water-ball : for we find, that the Light in the open Air, either in or out of the Sun-beams, and within a Room, either from one or many Windows, produces much -SOHOR the

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the fame effect : only where the Light is brighteft, there the Colours are most *vivid*. So does the light of a Candle, collected by a Glass-ball. And further, it is all one whatever fide of the coloured Rings be towards the light; for the whole Ring keeps its proper Colours from the middle outwards in the fame order as I before related, without varying at all, upon changing the position of the light.

But above all it is most observable, that here are all kind of Colours generated in a pellucid body, where there is properly no fuch refraction as Des Cartes supposes his Globules to acquire a verticity by : For in the plain and even Plates it is manifest, that the second refraction (according to Des Cartes his Principles in the fifth section of the eighth Chapter of his Meteors) does regulate and reftore the supposed turbinated Globules unto their former uniform motion. This Experiment therefore will prove fuch a one as our thrice excellent Verulam calls Experimentum Crucis, ferving as a Guide or Land-mark, by which to direct our courfe in the fearch after the true caufe of Colours. Affording us this particular negative Information, that for the production of Colours there is not neceflary either a great refraction, as in the Prifme; nor Secondly, a determination of Light and shadow, such as is both in the Prisme and Glassball. Now that we may fee likewife what affirmative and pofitive Inftruction it yields, it will be neceffary, to examine it a little more particularly and strictly; which that we may the better do, it will be requisite to premife fomewhat in general concerning the nature of Light and Refraction.

And first for Light, it seems very manifest, that there is no luminous Body but has the parts of it in motion more or less.

First, That all kind of fiery burning Bodies have their parts in motion, I think, will be very eafily granted me. That the fpark struck from a Flint and Steel is in a rapid agitation, I have elsewhere made probable. And that the Parts of rotten Wood, rotten Fift, and the like, are also in motion, I think, will as eafily be conceded by those, who confider, that those parts never begin to shine till the Bodies be in a state of putrefaction; and that is now generally granted by all, to be caufed by the motion of the parts of putrifying bodies. That the Bononian stone shines no longer then it is either warmed by the Sun-beams, or by the flame of a Fire or of a Candle, is the general report of those that write of it, and of others that have feen it. And that heat argues a motion of the internal parts, is (as I faid before) generally granted. But there is one Inftance more, which was first shewn to the Royal Society by Mr. Clayton a worthy Member thereof, which does make this Aflertion more evident then all the reft: And that is, That a Diamond being rub'd, ftruck, or heated in the dark, fhines for a pretty while after, fo long as that motion, which is imparted by any of those Agents, remains (in the fame manner as a Glafs, rubb'd, ftruck, or (by a means which I fhall elfewhere mention) heated, yields a found which lasts as long as the vibrating motion of that fonorous body) feveral Experiments made on which Stone, are fince published in a Discourse of Colours, by the truly honou-

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honourable Mr. Boyle. What may be faid of those Ignes fatui that appear in the night, I cannot fo well affirm, having never had the opportunity to examine them my felf, nor to be inform'd by any others that had observ'd them: And the relations of them in Authors are so imperfect, that nothing can be built on them. But I hope I shall be able in another place to make it at least very probable, that there is even in those also a Motion which causes this effect. That the shining of sea-water proceeds from the fame caufe, may be argued from this, That it fhines not till either it be beaten against a Rock, or be some other wayes broken or agitated by Storms, or Oars, or other percuffing bodies. And that the Animal Energyes or Spirituous agil parts are very active in Cats eyes when they fhine, feems evident enough, becaufe their eyes never fhine but when they look very intenfly either to find their prey, or being hunted in a dark room, when they feek after their adverfary, or to find a way to escape. And the like may be faid of the fhining Bellies of Gloworms, fince 'tis evident they can at pleafure either increase or extinguish that confequently the leaft apt to yield or beed, multi-c Radiation.

It would be fomewhat too long a work for this place Zetetically to examine, and politively to prove, what particular kind of motion it is that mult be the efficient of Light; for though it be a motion, yet 'tis not every motion that produces it, fince we find there are many bodies very violently mov'd, which yet afford not fuch an effect; and there are other bodies, which to our other fenfes, feem not mov'd fo much, which yet fhine. Thus Water and quick-filver, and most other liquors heated, fhine not; and feveral hard bodies, as Iron, Silver, Brass, Copper, Wood, \mathfrak{Sc} . though very often ftruck with a hammer, fhine not prefently, though they will all of them grow exceeding hot; whereas rotten Wood, rotten Fish, Sea water, Gloworms, \mathfrak{Sc} . have nothing of tangible heat in them, and yet (where there is no ftronger light to affect the Senfory) they fhine fome of them fo Vividly, that one may make a fhisft to read by them.

It would be too long, Ifay, here to infert the difcurfive progrefs by which I inquir'd after the proprieties of the motion of Light, and therefore I fhall only add the refult. And, Firft, I found it ought to be exceeding quick, fuch as those motions of fermentation and putrefaction, whereby, certainly, the parts are exceeding nimbly and violently mov'd; and that, because we find those motions are able more minutely to fhatter and divide the body, then the most violent heats or menstruums we yet know. And that fire is nothing elfe but fuch a dissolution of the Burning body, made by the most univerfal menstruum of all fulphureous bodies, namely, the Air, we shall in an other place of this Tractate endeavour to make probable. And that, in all extreamly hot shining bodies, there is a very quick motion that causes Light, as well as a more robust that causes Heat, may be argued from the celerity wherewith the bodyes are dissolved.

Next, it must be a Vibrative motion. And for this the newly mention'd Diamond affords us a good argument; fince if the motion of the parts did

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not return, the Diamond must after many rubbings decay and be wasted: but we have no reason to suspect the latter, especially if we confider the exceeding difficulty that is found in cutting or wearing away a Diamond. And a Circular motion of the parts is much more improbable, fince, if that were granted, and they be suppos'd irregular and Angular parts, I see not how the parts of the Diamond should hold fo firmly together, or remain in the same fensible dimensions, which yet they do. Next, if they be Globular, and mov'd only with a turbinated motion, I know not any cause that can impress that motion upon the pellucid medium, which yet is done. Thirdly, any other irregular motion of the parts one amongst another, must necessarily make the body of a fluid confistence, from which it is far enough. It must therefore be a Vibrating motion.

And Thirdly, That it is a very *fort vibrating motion*, I think the inftances drawn from the fhining of Diamonds will alfo make probable. For a Diamond being the hardeft body we yet know in the World, and confequently the leaft apt to yield or bend, must confequently alfo have its vibrations exceeding fhort.

And these, I think, are the three principal proprieties of a motion, requisite to produce the effect call'd Light in the Object.

The next thing we are to confider, is the way or manner of the trajetion of this motion through the interpos'd pellucid body to the eye: And here it will be eafily granted,

First, That it must be a body susceptible and impartible of this motion that will deferve the name of a Transparent. And next, that the parts of fuch a body must be Homogeneous, or of the fame kind. Thirdly, that the conftitution and motion of the parts must be such, that the appulse of the luminous body may be communicated or propagated through it to the greatest imaginable distance in the least imaginable time; though I fee no reason to affirm, that it must be in an instant : For I know not any one Experiment or observation that does prove it. And, whereas it may be objected, That we fee the Sun rifen at the very inftant when it is above the fenfible Horizon, and that we fee a Star hidden by the body of the Moon at the fame inftant, when the Star, the Moon, and our Eye are all in the fame line; and the like Observations, or rather suppositions, may be urg'd. I have this to answer, That I can as eafily deny as they affirm; for I would fain know by what means any one can be affured any more of the Affirmative, then I of the Negative. If indeed the propagation were very flow, 'tis poffible fomething might be difcovered by Eclypfes of the Moon; but though we should grant the progress of the light from the Earth to the Moon, and from the Moon back to the Earth again to be full two Minutes in performing, I know not any possible means to discover it ; nay, there may be some instances perhaps of Horizontal Eclypfes that may feem very much to favour this supposition of the flower progreffion of Light then most imagine. And the like may be faid of the Eclypses of the Sun, &c. But of this only by the by. Fourthly, That the motion is propagated every way through an Homogeneous

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geneous medium by direct or firaight lines extended every way like Rays from the center of a Sphere. Fifthly, in an Homogeneous medium this motion is propagated every way with equal velocity, whence neceflarily every pulfe or vitration of the luminous body will generate a Sphere, which will continually increase, and grow bigger, just after the fame manner (though indefinitely fwister) as the waves or rings on the furface of the water do fwell into bigger and bigger circles about a point of it, where, by the finking of a Stone the motion was begun, whence it neceflarily follows, that all the parts of these Spheres undulated through an Homogeneous medium cut the Rays at right angles.

But becaufe all transparent mediums are not Homogeneous to one another, therefore we will next examine how this pulfe or motion will be propagated through differingly transparent mediums. And here, according to the most acute and excellent Philosopher Des Cartes, I fuppose the fign of the angle of inclination in the first medium to be to the fign of refraction in the fecond, As the density of the first, to the density of the fecond. By density, I mean not the density in respect of gravity (with which the refractions or transparency of mediums hold no proportion) but in respect onely to the trajection of the Rays of light, in which respect they only differ in this; that the one propagates the pulse more easily and weakly, the other more flowly, but more strongly. But as for the pulses themselves, they will by the refraction acquire another propriety, which we shall now endeavour to explicate.

We will suppose therefore in the first Figure AC FD to be a physical Ray, or ABC and DEF to be two Mathematical Rays, trajected from a very remote point of a luminous body through an Homogeneous transparent medium LLL, and DA, EB, FC, to be fmall portions of the orbicular impulses which must therefore cut the Rays at right angles; these Rays meeting with the plain furface NO of a medium that yields an easier transitus to the propagation of light, and falling obliquely on it, they will in the medium MMM be refracted towards the perpendicular of the furface. And because this medium is more easily trajected then the former by a third, therefore the point C of the orbicular pulse FC will be mov'd to H four spaces in the same time that F the other end of it is mov'd to G three spaces, therefore the whole refracted pulse G H shall be oblique to the refracted Rays CHK and GI; and the angle GHC shall be an acute, and fo much the more acute by how much the greater the refraction be, then which nothing is more evident, for the fign of the inclination is to be the fign of refraction as GF to TC the diftance between the point C and the perpendicular from G on CK, which being as four to three, HC being longer then GF is longer also then TC, therefore the angle GHC is lefs than GTC. So that henceforth the parts of the pulses GH and IK are mov'd afcew, or cut the Rays at oblique angles.

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It is not my bufinefs in this place to fet down the reafons why this or that body fhould impede the Rays more, others lefs: as why Water fhould transmit the Rays more eafily, though more weakly than air. Onely thus K much

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much in general I fhall hint, that I fuppofe the medium MMM to have lefs of the transparent undulating fubtile matter, and that matter to be lefs implicated by it, whereas LLL I fuppofe to contain a greater quantity of the fluid undulating fubftance, and this to be more implicated with the particles of that medium.

But to proceed, the fame kind of *obliquity* of the Pulfes and Rays will happen alfo when the refraction is made out of a more eafie into a more difficult *medi* \tilde{u} ; as by the calculations of G Q & C S R which are refracted from the perpendicular. In both which calculations 'tis *obvious* to obferve, that always that part of the Ray towards which the refraction is made has the end of the *orbicular pulfe* precedent to that of the other fide. And always, the oftner the refraction is made the fame way. Or the greater the fingle refraction is, the more is this unequal progrefs. So that having found this odd propriety to be an infeparable concomitant of a refracted Ray, not ftreightned by a contrary refraction, we will next examine the refractions of the Sun-beams, as they are fuffer'd onely to pals through a fmall paffage, *obliquely* out of a more difficult, into a more eafie *medium*.

Let us suppose therefore ABC in the second Figure to represent a large Chimical Glass-body about two foot long, filled with very fair Water as high as A B, and inclin'd in a convenient posture with B towards the Sun: Let us further suppose the top of it to be cover'd with an opacous body, all but the hole a b, through which the Sun-beams are fuffer'd to pass into the Water, and are thereby refracted to c def, against which part, if a Paper be expanded on the outfide, there will appear all the colours of the Rain-bow, that is, there will be generated the two principal colours, Scarlet and Blue, and all the intermediate ones which arife from the composition and dilutings of these two, that is, c d shall exhibit a Scarlet, which toward d is diluted into a Tellow 3 this is the refraction of the Ray, ik, which comes from the underfide of the Sun; and the Ray ef shall appear of a deep Blue, which is gradually towards e diluted into a pale Watchet-blue. Between d and e the two diluted colours, Blue and Tellow are mixt and compounded into a Green; and this I imagine to be the reason why Green is so acceptable a colour to the eye, and that either of the two extremes are, if intense, rather a little offensive, namely, the being plac'd in the middle between the two extremes, and compounded out of both those, diluted also, or somewhat qualifi'd, for the composition, arising from the mixture of the two extremes undiluted, makes a Purple, which though it be a lovely colour, and pretty acceptable to the eye, yet is it nothing comparable to the ravishing pleasure with which a curious and well tempered Green affects the eye. If removing the Paper, the eye be plac'd against c d, it will perceive the lower fide of the Sun (or a Candle at night which is much better, because it offends not the eye, and is more eafily manageable) to be of a deep Red, and if against ef it will perceive the upper part of the luminous body to be of a deep Blue; and these colours will appear deeper and deeper, according as the Rays from the luminous body fall more obliquely on the furface of the Water, and thereby fuffer a greater refraction, and the more

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So that upon the whole, we fhall find that the reafon of the *Phænome-na* feems to depend upon the *obliquity* of the *orbicular pulfe*, to the Lines of Radiation, and in particular, that the Ray c d which conftitutes the *Scar-let* has its inner parts, namely those which are next to the middle of the luminous body, precedent to the outermost which are contiguous to the dark and *unradiating* sties. And that the Ray e f which gives a *Blue*, has its outward part, namely, that which is contiguous to the dark fkie precedent to the innermost, which borders on the bright area of the luminous body.

We may observe further, that the cause of the *diluting* of the colours towards the middle, proceeds partly from the wideness of the hole through which the Rays pass, whereby the Rays from several parts of the luminous body, fall upon many of the fame parts between r and f as is more manifest by the Figure : And partly also from the nature of the refraction it felf, for the vividness or strength of the two terminating colours, arising chiefly as we have seen, from the very great difference that is betwixt the outfides of those oblique undulations & the dark Rays circumambient, and that disparity betwixt the approximate Rays, decaying gradually : the further inward toward the middle of the luminous body they are remov'd, the more must the colour approach to a white or an undisfurbed light.

Upon the calculation of the refraction and reflection from a Ball of Water or Glafs, we have much the fame *Phanomena* namely, an *obliquity* of the undulation in the fame manner as we have found it here. Which, becaufe it is very much to our prefent purpofe, and affords fuch an *Infrancia crucis*, as no one that I know has hitherto taken notice of, I fhall further examine. For it does very plainly and politively diffinguifh, and fhew, which of the two *Hypothefes*, either the *Cartefian* or this is to be followed, by affording a generation of all the colors in the Rainbow, where according to the *Cartefian Principles* there fhould be none at all generated. And fecondly, by affording an infrance that does more clofely confine the caufe of thefe *Phanomena* of colours to this prefent *Hypothefes*.

And first, for the Cartefian, we have this to object against it, That whereas he fays (Meteorum Cap. 8. Sect. 5.) Sed judicabam unicam (refractione fcilicet) ad minimű requiri, & quidem talem ut ejus effectus alià contrarià (refractione) non destruatur : Nam experientia docet si superficies NM & NP (nempe refringentes) Parallelæ forent, radios tantundem per alteram iterum erectos quantum per unam frangerentur, nullos colores depicturos; This Principle of his holds true indeed in a prisme where the refracting surfaces are plain, but is contradicted by the Ball or Cylinder, whether of Water or Glass, where the refracting surfaces are Orbicular or Cylindrical. For if we examine the passe of any Globule or Ray of the primary Iris, we shall find it to pass out of the Ball or Cylinder again, with the fame inclination and refraction that it enter'd in withall, and that that last refraction by means of the intermediate reflection shall be the fame as if without any reflection at all the Ray had been twice refracted by two Parallel furfaces.

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Schem. 6. Fig. 3.

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And that this is true, not onely in one, but in every Ray that goes to the conftitution of the Primary Iris; nay, in every Ray, that fuffers only two refractions, and one reflection, by the furface of the round body, we shall presently see most evident, if we repeat the Cartesian Scheme, mentioned in the tenth section of the eighth Chapter of his Meteors, where EFKNP in the third Figure is one of the Rays of the Primary Iris, twice refracted at F and N, and once reflected at K by the furface of the Water-ball. For, first it is evident, that KF and KN are equal, because K N being the reflected part of K F they have both the fame inclination on the furface K that is the angles F K T, and N K V made by the two Rays and the Tangent of K are equal, which is evident by the Laws of reflection ; whence it will follow alfo, that K N has the fame inclination on the furface N, or the Tangent of it X N that the Ray KF has to the furface F, or the Tangent of it FY, whence it must necessarily follow, that the refractions at F and N are equal, that is, KFE and KNP are equal. Now, that the furface N is by the reflection at K made parallel to the furface at F, is evident from the principles of reflection; for reflection being nothing but an inverting of the Rays, if we re-invertthe Ray KNP, and make the fame inclinations below the line TKV that it has above, it will be most evident, that K H the inverse of K N will be the continuation of the line FK, and that LHI the inverse of OX is parallel to FY. And HM the inverse of NP is Parallel to EF for the angle KHI is equal to KNO which is equal to KFY, and the angle KHM is equal to KNP which is equal to KFE which was to be prov'd.

So that according to the above mentioned *Cartefian* principles there fhould be generated no colour at all in a Ball of Water or Glafs by two refractions and one reflection, which does hold most true indeed, if the furfaces be plain, as may be experimented with any kind of prisme where the two refracting furfaces are equally inclined to the reflecting; but in this the *Phanomena* are quite otherwise.

The caufe therefore of the generation of colour must not be what Des Cartes affigns, namely, a certain rotation of the Globuli ætherei, which are the particles which he fuppofes to conftitute the Pellucid medium, But fomewhat elfe, perhaps what we have lately fuppofed, and fhall by and by further profecute and explain.

But, First I shall crave leave to propound some other difficulties of his, notwithstanding exceedingly ingenious Hypothesis, which I plainly confess to me seem such; and those are,

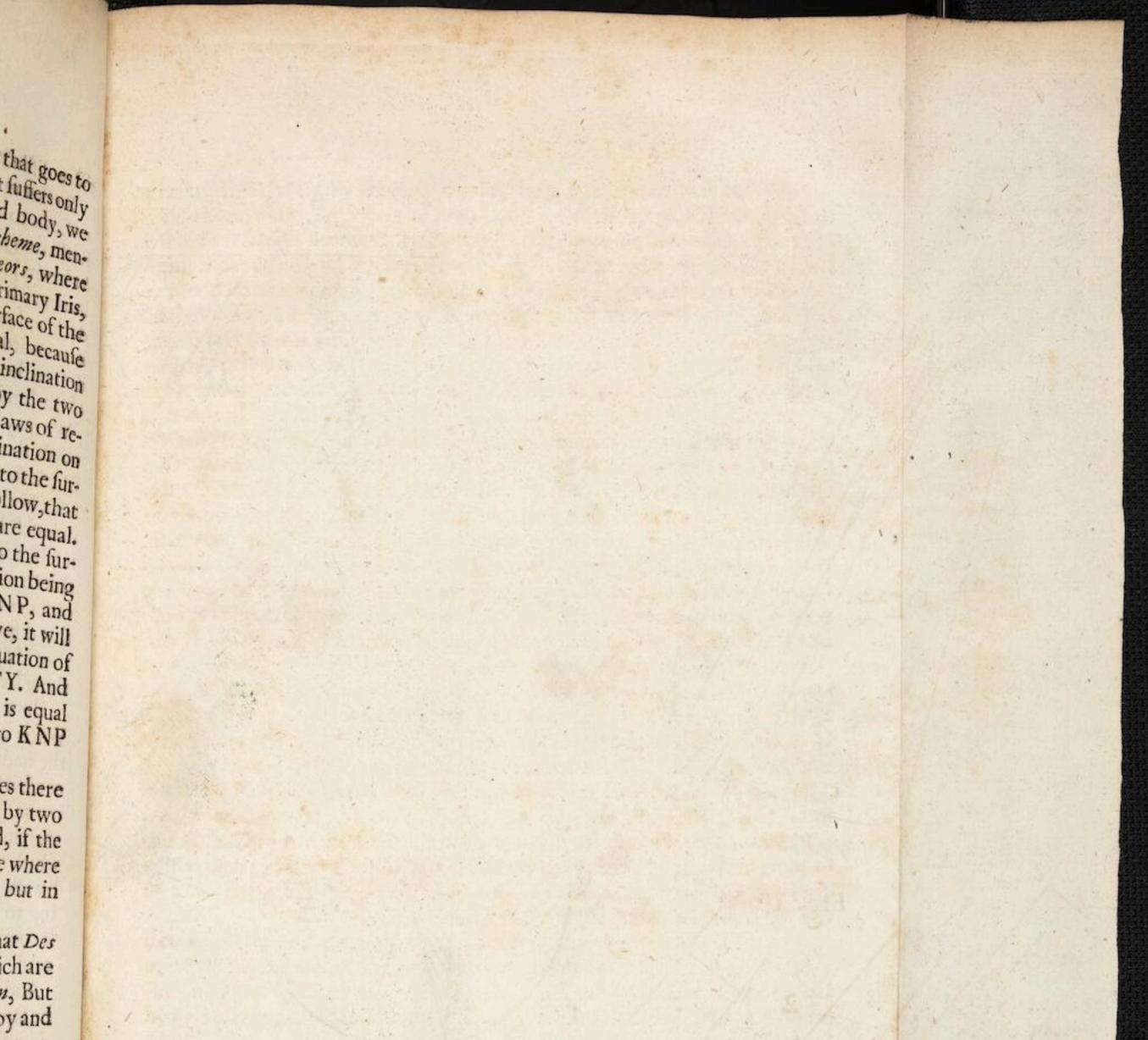
First, if that light be (as is affirmed, *Diopt.* cap. 1. §. 8.) not fo properly a motion, as an action or propension to motion, I cannot conceive how the eye can come to be fensible of the *verticity* of a *Globule*, which is generated in a drop of Rain, perhaps a mile off from it. For that *Globule* is not carry'd to the eye according to his formerly recited Principle; and if not fo,I cannot conceive how it can communicate its *rotation*, or circular motion to the line of the *Globules* between the drop and the eye. It cannot be by means of every ones turning the next before him; for if fo, then onely all the *Globules* that are in the odd places must be turned the fame

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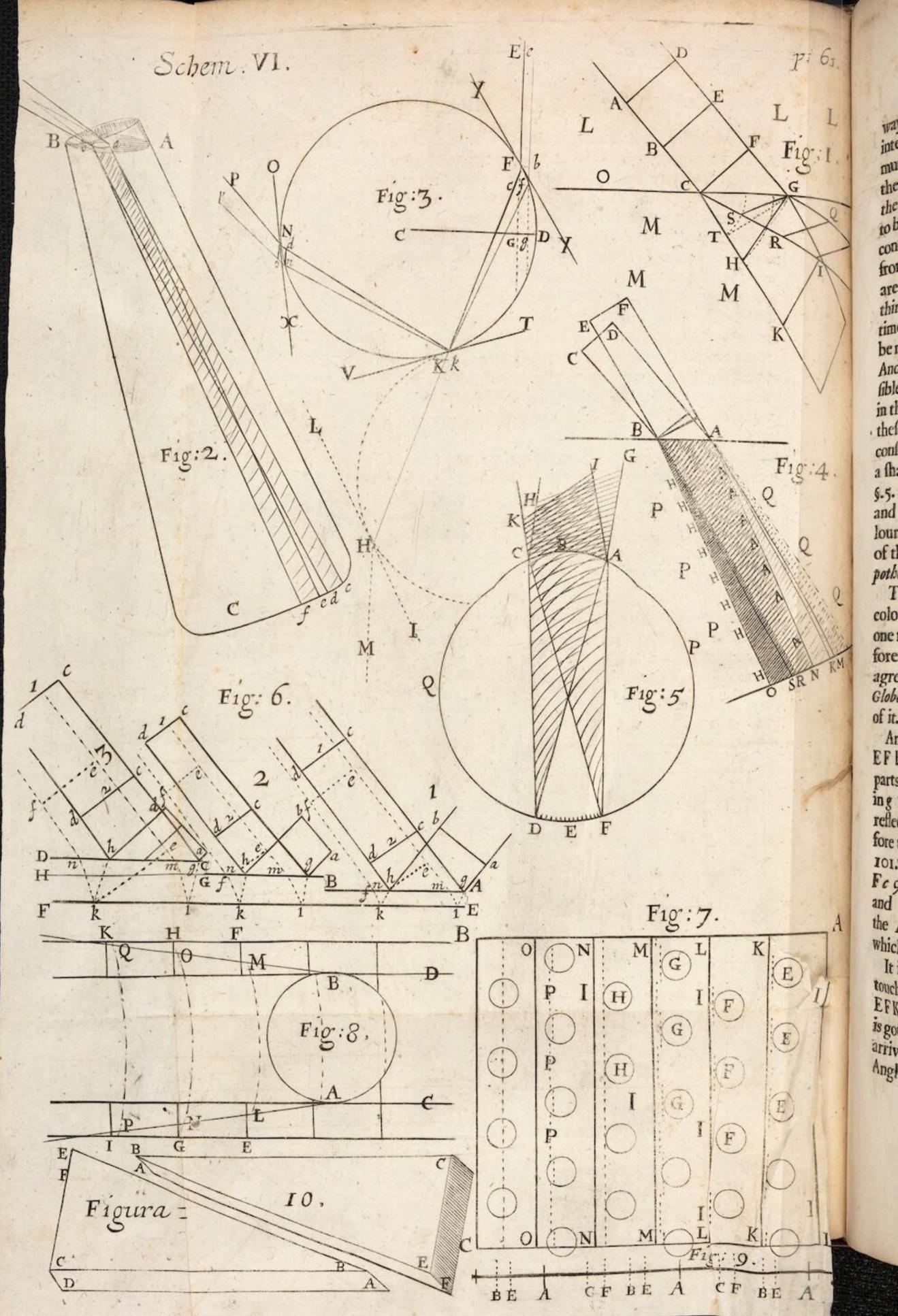
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way with the first, namely, the 3.5. 7.9. 11, Ge. but all the Globules interpolited between them in the even places; namely, the 2.4.6.8.10.6%. must be the quite contrary; whence, according to the Cartefian Hypothesis, there must be no diffinct colour generated, but a confusion. Next, fince the Cartesian Globuli are suppos'd (Principiorum Philosoph. Part. 3. §. 86.) to be each of them continually in motion about their centers, I cannot conceive how the eye is able to diffinguish this new generated motion from their former inherent one, if I may fo call that other wherewith they are mov'd or turbinated, from some other cause than refraction. And thirdly, I cannot conceive how these motions should not happen sometimes to oppose each other, and then, in stead of a rotation, there would be nothing but a direct motion generated, and confequently no colour. And fourthly, I cannot conceive, how by the Cartefian Hypothesis it is posfible to give any plaufible reafon of the nature of the Colours generated in the thin lamina of these our Microscopical Observations; for in many of · these, the refracting and reflecting furfaces are parallel to each other, and confequently no rotation can be generated, nor is there any necessity of a shadow or termination of the bright Rays, such as is suppos'd (Chap. 8. §.5. Et preterea observavi umbram quoque, aut limitationem luminis requiri : and chap. 8. §. 9.) to be neceffary to the generation of any diftinct colours; Befides that, here is oftentimes one colour generated without any of the other appendant ones, which cannot be by the Cartesian Hypothefts.

There must be therefore some other propriety of refraction that causes colour. And upon the examination of the thing, I cannot conceive any one more general, inseparable, and sufficient, than that which I have before affign'd. That we may therefore see how exactly our Hypothesis agrees also with the *Phænomena* of the refracting round body, whether Globe or Cylinder, we shall next subjoyn our Calculation or Examen of it.

And to this end, we will calculate any two Rays: as for inftance ; let schem. 6. EF be a Ray cutting the Radius CD (divided into 20. parts) in G 16. Fig. 3. parts distant from C, and ef another Ray, which cuts the same Radius ing 17. parts distant, these will be refracted to K and k, and from thence reflected to N and n, and from thence refracted toward P and p; therefore the Arch Ff will be 5.d 5'. The Arch FK 106.d 30'. the Arch fk 101.^d 2'. The line F G 6000. and f g 5267. therefore h f. 733. therefore Fc 980, almost. The line FK 16024. and f k 15436. therefore Nd 196: and no 147 almost, the line Nn 1019 the Arch Nn 5.d 51'. therefore the Angle Nnois 34.d 43'. therefore the Angle Non. is 139.d 56'. which is almost 50.d more than a right Angle. It is evident therefore by this Hypothesis, that at the same time that ef touches f. EF is arrived at c. And by that time e f k n is got to n, EFKN is got to d, and when it touches N, the pulle of the other Ray is got to o, and no farther, which is very fhort of the place it fhould have arrivd to, to make the Ray np to cut the orbicular pulle. No at right Angles : therefore the Angle Nop is an acute Angle, but the quite contrary

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trary of this will happen, if 17. and 18. be calculated in ftead of 16. and 17. both which does most exactly agree with the Phanomena : For if the Sun, or a Candle (which is better) be placed about E e, and the eye about P p, the Rays E F ef. at 16. and 17. will paint the fide of the luminous object toward np Blue, and towards N P Red. But the quite contrary will happen when EF is 17. and ef 18. for then towards NP shall be a Blue, and towards np a Red, exactly according to the calculation. And there appears the Blue of the Rainbow, where the two Blue fides of the two Images unite, and there the Red where the two Red fides unite, that is, where the two Images are just disappearing; which is, when the Rays EF and NP produc'd till they meet, make an Angle of about 41. and an half; the like union is there of the two Images in the Production of the Secundary Iris, and the fame caufes, as upon calculation may appear; onely with this difference, that it is fomewhat more faint, by reafon of the duplicate reflection, which does always weaken the impulse the oftner it is repeated.

Now, though the fecond refraction made at Nn be convenient, that is, do make the Rays glance the more, yet is it not altogether requifite; for it is plain from the calculation, that the pulfe dn is fufficiently oblique to the Rays K N and kn, as wel as the pulfe fc is oblique to the Rays F K & fk. And therefore if a piece of very fine Paper be held clofe againft Nn and the eye look on it either through the Ball as from D, or from the other fide, as from B. there fhall appear a Rainbow, or colour'd line painted on it with the part toward X appearing Red, towards O, Blue; the fame alfo fhall happen, if the Paper be placed about K k, for towards T fhall appear a Red, and towards V a Blue, which does exactly agree with this my Hypothefis, as upon the calculation of the progrefs of the pulfe will moft eafily appear.

Nor do these two observations of the colours appearing to the eye about p differing from what they appear on the Paper at N contradict each other; but rather confirm and exactly agree with one another, as will be evident to him that examines the reasons fet down by the ingenious. Des Cartes in the 12. sect. of the 8. Chapter of his Meteors, where he gives the true reafon why the colours appear of a quite contrary order to the eye, to what they appear'd on the Paper if the eye be plac'd in steed of the Paper : And as in the Prisme, so also in the Water, Drop, or Globe the Phanomena and reason are much the fame. Having therefore fhewn that there is fuch a propriety in the prifme and water Globule whereby the pulse is made oblique to the progressive, and that fo much the more, by how much greater the refraction is, I shall in the next place confider, how this conduces to the production of colours, and what kind of impreffion it makes upon the bottom of the eye; and to this end it will be requifite to examine this Hypothesis a little more particularly. First therefore, if we confider the manner of the progress of the pulse, it will feem rational to conclude, that that part or end of the pulle which precedes the other, must necessarily be fomwhat more obtunded, or impeded by

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by the refiftance of the transparent medium, than the other part or end of it which is subsequent, whose way is, as it were, prepared by the other; efpecially if the adjacent medium be not in the fame manner enlightned, or agitated. And therefore (in the fourth Figure of the fixth Iconifm) the Ray AAAHB will have its fide HH more deadned by the refiftance of the dark or quiet medium PPP, Whence there will be a kind of deadnels superinduc'd on the side HHH, which will continually increase from B, and strike deeper and deeper into the Ray by the line BR; Whence all the parts of the triangle, R BHO will be of a dead Blue colour, and fo much the deeper, by how much the nearer they lie to the line BHH, which is most deaded or impeded, and fo much the more dilute, by how much the nearer it approaches the line BR. Next on the other fide of the Ray AAN, the end A of the pulse AH will be promoted, or made ftronger, having its paflage already prepar'd as 'twere by the other parts preceding, and fo its imprefficn wil be ftronger; And becaufe of its obliquity to the Ray, there will be propagated a kind of faint motion into QQ the adjacent dark or quiet medium, which faint motion will fpread further and further into QQ as the Ray is propagated further and further from A, namely, as far as the line M A, whence all the triangle M A N will be ting'd with a Red, and that Red will be the deeper the nearer it approaches the line MA, and the paler or yellower the nearer it is the line NA. And if the Ray be continued, fo that the lines A N and BR (which are the bounds of the Red and Blue diluted) do meet and crofs each other, there will be beyond that interfection generated all kinds of Greens.

Now, these being the proprieties of every single refracted Ray of light, it will be easie enough to confider what must be the refult of very many fuch Rays collateral : As if we suppose infinite such Rays interjacent between AKSB and ANOB, which are the terminating: For in this cafe the Ray A K S B will have its Red triangle intire, as lying next to the dark or quiet medium, but the other fide of it BS will have no Blue, becaufe the medium adjacent to it SBO, is mov'd or enlightned, and confequently that light does deftroy the colour. So likewife will the Ray ANOB lofe its Red, because the adjacent medium is mov'd or enlightned, but the other fide of the Ray that is adjacent to the dark, namely, AHO will preferve its Blue entire, and these Rays must be fo far produc'd as till AN and BR cut each other, before there will be any Green produc'd. From these Proprieties well confider'd, may be deduc'd the reasons of all the Phanomena of the prisme, and of the Globules or drops of Water which conduce to the production of the Rainbow. Next for the impression they make on the Retina, we will further examine this Hypothesis : Suppose therefore ABCDEF. in the fifth Figure, to represent the Ball of the eye: on the Cornea of which ABC two Rays GACH and KCAI (which are the terminating Rays of a luminousbody) falling, are by the refraction thereof collected or converg'd into two points at the bottom of the eye. Now, because these terminating Rays, and all the intermediate ones which come from any part of the luminous body, are fuppos'd by fome fufficient refraction before they .Dalimong water

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enter the eye, to have their pulses made oblique to their progression, and confequently each Ray to have potentially superinduc'd two proprieties, or colours, viz. a Red on the one fide, and a Blue on the other, which notwithstanding are never actually manifest, but when this or that Ray has the one or the other fide of it bordering on a dark or unmov'd medium, therefore as foon as these Rays are entred into the eye, and so have one fide of each of them bordering on a dark part of the humours of the eye, they will each of them actually exhibit fome colour; therefore ADC the production GACH will exhibit a Blue, because the fide CD is adjacent to the dark mediumCQDC, but nothing of a Red, because its fide A D is adjacent to the enlightned medium ADFA: And all the Rays that from the points of the luminous body are collected on the parts of the Retina between D and F shall have their Blue fo much the more diluted by how much the farther these points of collection are distant from D towards F; and the Ray AFC the production of KCAI, will exhibit a Red, because the fide AF is adjacent to the dark or quiet medium of the eye APFA, but nothing of a Blue, because its fide CF is adjacent to the enlightned medium CFDC, and all the Rays from the intermediate parts of the luminous body that are collected between F and D shall have their Red so much the more diluted, by how much the farther they are diftant from F towards D.

Now, because by the refraction in the Cornea, and some other parts of the eye, the fides of each Ray, which before were almost parallel, are made to converge and meet in a point at the bottom of the eye, therefore that fide of the pulle which preceded before these refractions, shall first touch the Retina, and the other fide laft. And therefore according as this or that fide, or end of the pulse shall be impeded, accordingly will the impressions on the Retina be varied; therefore by the Ray GACH refracted by the Cornea to D there shall be on that point a stroke or impreffion confus'd, whole weakeft end, namely, that by the line CD shall precede, and the ftronger, namely, that by the line AD shall follow. And by the Ray KCAI refracted to F, there shall be on that part a confus'd ftroke or impreffion, whole ftrongeft part, namely, that by the line CF fhal precede, and whofe weakeft or impeded, namely, that by the line A F shall follow, and all the intermediate points between F and D will receive impression from the converg'd Rays fo much the more like the impreffions on F and D by how much the nearer they approach that or this. From the confideration of the proprieties of which impreffions, we may collect these short definitions of Colours : That Blue is an impression on the Retina of an oblique and confus'd pulse of light, whose weakest part precedes, and whose strongest follows. And, that Red is an impression on the Retina of an oblique and confus'd pulfe of light, whose strongest part precedes, and whose weakest follows. Which proprieties, as they have been already manifested, in the Prisme and falling drops of Rain, to be the causes of the colours there generated, may be eafily found to be the efficients also of the colours appearing in thin laminated transparent bodies; for the explication of which, all this has been premifed. And

An the Fi Foi ofad termi of tho grows forIh pearc thick have 1 pends the co tals;] as in th transpa low, Gi Blue, I but in io ma And this Ia at all try'd, of Gla then w Thi under the gi colour From under (thefe co further great t indeed fhew n withou magni ceedin their t pothetic Let thinner pole th object flected

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And that this is fo, a little closer examination of the Phenomena and the Figure of the body, by this Hypothesis, will make evident.

For first (as we have already observed) the laminated body must be of a determinate thickness, that is, it must not be thinner then such a determinate quantity; for I have always observ'd, that neer the edges of those which are exceeding thin, the colours disappear, and the part grows white; nor must it be thicker then another determinate quantity; for I have likewife obferv'd, that beyond fuch a thickness, no colours appear'd, but the Plate looked white, between which two determinate thickneffes were all the colour'd Rings; of which in fome fubftances I have found ten or twelve, in others not half fo many, which I suppose depends much upon the transparency of the laminated body. Thus though the confecutions are the fame in the fcumm or the fkin on the top of metals; yet in those confecutions the fame colour is not fo often repeated as in the confecutions in thin Glafs, or in Sope-water, or any other more transparent and glutinous liquor; for in these I have observ'd, Red, Yellow, Green, Blue, Purple; Red, Yellow, Green, Blue, Purple; Red, Yellow, Green, Blue, Purple ; Red, Tellow, &c. to fucceed each other, ten or twelve times, but in the other more opacous bodies the confecutions will not be half lo many.

And therefore fecondly, the *laminated* body must be transparent, and this I argue from this, that I have not been able to produce any colour at all with an *opacous* body, though never fo thin. And this I have often try'd, by preffing a fmall *Globule* of *Mercury* between two fmooth Plates of Glass, whereby I have reduc'd that body to a much greater thinnels then was requisite to exhibit the colours with a transparent body.

Thirdly, there must be a confiderable reflecting body adjacent to the under or further fide of the *lamina* or *plate*: for this I always found, that the greater that reflection was, the more vivid were the appearing colours.

From which Observations, it is most evident, that the reflection from the under or further fide of the body is the principal caufe of the production of thefe colours; which, that it is fo, and how it conduces to that effect, I shall further explain in the following Figure, which is here defcribed of a very great thickness, as if it had been view'd through the Microfcope ; and 'tis indeed much thicker than any Microfcope (I have yet us'd) has been able to fhew me those colour'd plates of Glass, or Muscovie-glass, which I have not without much trouble view'd with it; for though I have endeavoured to magnifie them as much as the Glaffes were capable of, yet are they to exceeding thin, that I have not hitherto been able politively to determine their thickness. This Figure therefore I here represent, is wholy Hypothetical. Let ABCDHFE in the fixth Figure be a frustum of Muscovy-glas, thinner toward the end AE, and thicker towards DF. Let us firlt fuppole the Ray aghb coming from the Sun, or some remote luminous object to fall obliquely on the thinner plate BAE, part therefore is reflected back, by cghd, the first superficies; whereby the perpendicular pulle

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pulle *a b* is after reflection propagated by *c d*, *c d*, equally remote from each other with *a b*, *a b*, fo that ag + gc, or bh + bd are either of them equal to *a a*, as is alfo *c c*, but the body BAE being transparent, a part of the light of this Ray is refracted in the furface AB, and propagated by gikb to the furface EF, whence it is reflected and refracted again by the furface AB. So that after two refractions and one reflection, there is propagated a kind of fainter Ray emnf, whose pulle is not only weaker by reason of the two refractions in the furface AB, but by reason of the time spent in passing and repatsing between the two suffaces A B and EF, *e f* which is this fainter or weaker pulse comes behind the pulse *c d*; fo that hereby (the suffaces AB, and EF being so neer together, that the eye cannot *discriminate* them from one) this confus'd or *duplicated* pulse, whose strongest part precedes, and whose weakest follows, does produce on the *Retina* (or the *optick nerve* that covers the bottom of the eye) the fensation of a *Tellom*.

And fecondly, this *Tellow* will appear fo much the deeper, by how much the further back towards the middle between cd and cd the fpurious pulfe ef is remov'd, as in 2 where the furface BC being further remov'd from EF, the weaker pulfe ef will be nearer to the middle, and will make an imprefiion on the eye of a *Red*.

But thirdly, if the two reflecting furfaces be yet further remov'd afunder'(as in 3 CD and EF are) then will the weaker pulfe be fo farr behind, that it will be more then half the diftance between cd and cd. And in this cafe it will rather feem to precede the following ftronger pulfe, then to follow the preceding one, and confequently a *Blue* will be generated. And when the weaker pulfe is juft in the middle beween two ftrong ones, then is a deep and lovely *Purple* generated; but when the weaker pulfe *ef* is very neer to cd, then is there generated a *Green*, which will be *bluer*, or *yellower*, according as the *approximate* weak pulfe does precede or follow the ftronger.

Now fourthly, if the thicker Plate chance to be cleft into two thinner Plates, as CDFE is divided into two Plates by the furface GH then from the composition arising from the three reflections in the furfaces CD, GH, and EF, there will be generated feveral compounded or mixt colours, which will be very differing, according as the proportion between the thickneffes of those two divided Plates CDHG, and GHFE are varied. And fifthly, if these furfaces CD and FE are further remov'd asunder, the weaker pulfe will yet lagg behind much further, and not onely be coincident with the fecond, cd, but lagg behind that also, and that fo much the more, by how much the thicker the Plate be; fo that by degrees it will be coincident with the third cd backward alfo, and by degrees, as the Plate grows thicker with a fourth, and fo onward to a fifth, fixth, feventh, or eighth; fo that if there be a thin transparent body, that from the greatest thinness requisite to produce colours, does, in the manner of a Wedge, by degrees grow to the greatest thickness that a Plate can be of to exhibit a colour by the reflection of Light from fuch a body, there fhall

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shall be generated feveral confecutions of colours, whole order from the thin end towards the thick, shall be Yellow, Red, Purple, Blue, Green; Yellow, Red, Purple, Blue, Green ; Tellow, Red, Purple, Blue, Green; Tellow, &c. and thefe fo often repeated, as the weaker pulle does lofe paces with its Primary; or first pulse, and is coincident with a second, third, fourth, fifth, fixth, O.c. pulse behind the first. And this, as it is coincident, or follows from the first Hypothesis I took of colours, so upon exeriment have I found it in multitudes of inftances that feem to prove it. One thing which feems of the greatest concern in this Hypothesis, is to determine the greatest or least thickness requisite for these effects, which, though I have not been wanting in attempting, yet fo exceeding thin are these coloured Plates, and so imperfect our Microscope, that I have not been hitherto fuccessfull, though if my endeavours shall answer my expectations, I shall hope to gratifie the curious Reader with some things more remov'd beyond our reach hitherto.

Thus have I, with as much brevity as I was able, endeavoured to explicate (Hypothetically at least) the causes of the Phanomena I formerly recited, on the confideration of which I have been the more particular.

First, because I think these I have newly given are capable of explicating all the Phanomena of colours, not onely of those appearing in the Prisme, Water-drop, or Rainbow, and in laminated or plated bodies, but of all that are in the world, whether they be fluid or folid bodies, whether in thick or thin, whether transparent, or feemingly opacous, as I shall in the next Observation further endeavour to shew. And secondly, because this being one of the two ornaments of all bodies discoverable by the fight, whether looked on with, or without a Microscope, it seem'd to deferve (somewhere in this Tract, which contains a description of the Figure and Colour of fome minute bodies) to be fomewhat the more intimately enquir'd into.

Observ. X. Of Metalline, and other real Colours.

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Aving in the former Discourse, from the Fundamental cause of Co-I lour, made it probable, that there are but two Colours, and fhewn, that the Phantasm of Colour is caus'd by the sensation of the oblique or uneven pulle of Light which is capable of no more varieties than two that arife from the two fides of the oblique pulse, though each of those be capable of infinite gradations or degrees (each of them beginning from White, and ending the one in the deepest Scarlet or Yellow, the other in the deepest Blue) I shall in this Section set down some Observations which I have made of other colours, fuch as Metalline powders tinging or colour d bodies and several kinds of tinctures or ting'd liquors, all which, together with those I treated of in the former Observation will, I suppose, comprise the several subjects in which colour is observed to be inherent, and the feveral manners by which it inheres, or is apparent L 2

in them. And here I ihall endeavour to fhew by what composition all kind of compound colours are made, and how there is no colour in the world but may be made from the various degrees of these two colours, together with the intermixtures of *Black* and *White*.

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And this being fo, as I fhall anon fhew, it feems an evident argument to me, that all colours whatfoever, whether in fluid or folid, whether in very transparent or feemingly opacous, have the fame efficient caufe, to wit, fome kind of refraction whereby the Rays that proceed from fuch bodies, have their pulfe obliquated or confus'd in the manner I explicated in the former section; that is, a Red is caus'd by a duplicated or confus'd pulfe, whose ftrongest pulse precedes, and a weaker follows : and a Blue is caus'd by a confus'd pulse, where the weaker pulse precedes, and the scaus'd by a confus'd pulse, where the weaker pulse precedes, and the ftronger follows. And according as these are, more or lefs, or variously mixt and compounded, fo are the fensations, and confequently the phantas of colours diversified.

To proceed therefore; I suppose, that all transparent colour'd bodies, whether fluid or folid, do confift at leaft of two parts, or two kinds of fubstances, the one of a substance of a somewhat differing refraction from the other. That one of these substances which may be call'd the tinging substance, does confist of distinct parts, or particles of a determinate bigness which are disseminated, or dispers'd all over the other : That these particles, if the body be equally and uniformly colour'd, are evenly rang'd and dispers'd over the other contiguous body ; That where the body is deepest ting'd, there these particles are rang'd thickest; and where 'tis but faintly ting'd, they are rang'd much thinner, but uniformly. That by the mixture of another body that unites with either of thefe, which has a differing refraction from either of the other, quite differing effects will be produc'd, that is, the confecutions of the confus d pulses will be much of another kind, and confequently produce other fenfations and phantasms of colours, and from a Red may turn to a Blue, or from a Blue to a Red, &c.

Now, that this may be the better underftood, I fhall endeavour to explain my meaning a little more fenfible by a scheme : Suppose we therefore in the seventh Figure of the fixth scheme, that ABCD represents a Veffel holding a ting'd liquor, let I I I I,&c. be the clear liquor, and let the tinging body that is mixt with it be EE, &c. FF, &c.GG, &c. HH, &c. whole particles (whether round, or some other determinate Figure is little to our purpose) are first of a determinate and equal bulk. Next, they are rang'd into the form of Quincunx, or Equilaterotriangular order, which that probably they are fo, and whythey are fo, I shall elfewhere endeavour to shew. Thirdly, they are of such a nature, as does either more eafily or more difficultly transmit the Rays of light then the liquor; if more eafily, a Blue is generated, and if more difficultly, a Red or Scarlet. And first, let us suppose the tinging particles to be of a substance that does more impede the Rays of light, we shall find that the pulse or wave of light mov'd from A D to B C, will proceed on, through the containing medium by the pulses or waves KK, LL, MM, NN, OO; but becaufe

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because several of these Rays that go to the constitution of these pulses will be flugged or stopped by the tinging particles E.F.G.H; therefore there shall be a *secundary* and weak pulse that shall follow the Ray, namely P P which will be the weaker: first, because it has suffer'd many refractions in the impeding body; next, for that the Rays will be a little dispers'd or confus'd by reason of the refraction in each of the particles, whether round or angular; and this will be more evident, if we a little more closely examine any one particular tinging *Globule*.

Suppose we therefore A B in the eighth Fgure of the fixth Scheme, to represent a tinging Globule or particle which has a greater refraction than the liquor in which it is contain'd: Let CD be a part of the pulse of light which is propagated through the containing medium; this pulse will be a little ftopt or impeded by the Globule, and so by that time the pulse is pass to E F that part of it which has been impeded by passing through the Globule, will get but to L M, and so that pulse which has been propagated through the Globule, to wit, L M, NO, PQ, will always come behind the pulses EF, GH, IK, $\mathcal{O}c$.

Next, by reafon of the greater impediment in A B, and its Globular Figure, the Rays that pafs through it will be difpers'd, and very much fcatter'd. Whence C A and D B which before went direct and parallel, will after the refraction in A B, diverge and fpread by A P, and B Q; fo that as the Rays do meet with more and more of these tinging particles in their way, by fo much the more will the pulse of light further lagg behind the clearer pulse, or that which has fewer refractions, and thence the deeper will the colour be, and the fainter the light that is trajected through it; for not onely many Rays are reflected from the furfaces of A B, but those Rays that get through it are very much difordered.

By this Hypobesis there is no one experiment of colour that I have yet met with, but may be, I conceive, very rationably folv'd, and perhaps, had I time to examine feveral particulars requifite to the demonstration of it, I might prove it more than probable, for all the experiments about the changes and mixings of colours related in the Treatife of Colours, published by the Incomparable Mr. Boyle, and multitudes of others which I have observ'd, do so easily and naturally flow from those principles, that I am very apt to think it probable, that they own their production to no other fecundary cause : As to instance in two or three experiments. In the twentieth Experiment, this Noble Authour has fhewn that the deep bluish purple-colour of Violets, may be turn'd into a Green, by Alcalizate Salts, and to a Red by acid; that is, a Purple confifts of two colours, a deep Red, and a deep Blue; when the Blue is diluted, or altered, or deftroy'd by acid Salts, the Red becomes predominant, but when the Red is diluted by Alcalizate, and the Blue heightned, there is generated a Green; for of a Red diluted, is made a Tellow, and Tellow and Blue make a Green. Now, because the spurious pulses which cause a Red and a Blue, do the one follow the clear pulse, and the other precede it, it usually follows, that those saline refracting bodies which do dilute the colour of the one, do deepen that of the other. And this will be made manifest by almolt

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most all kinds of Purples, and many forts of Greens, both these colours confifting of mixt colours; for if we suppose A and A in the ninth Figure, to reprefent two pulses of clear light, which follow each other at a convenient distance, A A, each of which has a spurious pulse preceding it, as BB, which makes a Blue, and another following it, as CC, which makes a Red, the one caus'd by tinging particles that have a greater refraction, the other by others that have a lefs refracting quality then the liquor or Menstruum in which these are difiolv'd, whatfoever liquor does fo alter the refraction of the one, without altering that of the other part of the ting'd liquor, must needs very much alter the colour of the liquor; for if the refraction of the diffolvent be increas'd, and the refraction of the tinging particles not altered, then will the preceding furious pulse be fhortned or ftopt, and not out-run the clear pulse fo much; fo that BB will become EE, and the Blue be diluted, whereas the other fourious pulse which follows will be made to lagg much more, and be further behind A A than before, and CC will become f f, and fo the Tellow or Red will be heightned.

A saline liquor therefore, mixt with another ting'd liquor, may alter the colour of it feveral ways, either by altering the refraction of the liquor in which the colour fwims : or fecondly by varying the refraction of the coloured particles, by uniting more intimately either with fome particular corpufcles of the tinging body, or with all of them, according as it has a congruity to fome more especially, or to all alike: or thirdly, by uniting and interweaving it felf with fome other body that is already joyn'd with the tinging particles, with which fubstance it may have a congruity, though it have very little with the particles themfelves : or fourthly, it may alter the colour of a ting'd liquor by dif-joyning certain particles which were before united with the tinging particles, which though they were fomewhat congruous to these particles, have yet a greater congruity with the newly infus d Saline menstruum. It may likewise alter the colour by further diffolving the tinging fubftance into fmaller and fmaller particles, and fo diluting the colour; or by uniting feveral particles together as in precipitations, and fo deepning it, and fome fuch other ways, which many experiments and comparisons of differing trials together, might eafily inform one of.

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• From these Principles applied, may be made out all the varieties of colours observable, either in liquors, or any other ting'd bodies, with great ease, and I hope intelligible enough, there being nothing in the *notion* of colour, or in the suppos'd production, but is very conceivable, and may be possible.

The greateft difficulty that I find againft this Hypothesis, is, that there feem to be more distinct colours then two, that is, then Yellow and Blue. This Objection is grounded on this reason, that there are several Reds, which diluted, make not a Saffron or pale Yellow, and therefore Red, or Scarlet seems to be a third colour distinct from a deep degree of Yellow. To which I answer, that Saffron affords us a deep Scarlet tincture, which may be diluted into as pale a Yellow as any, either by making a weak folution

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Intion of the Saffron, by infufing a fmall parcel of it into a great quantity of liquor, as in fpirit of Wine, or elfe by looking through a very thin quantity of the tincture, and which may be heightn'd into the lovelieft Scarlet, by looking through a very thick body of this tincture, or through a thinner parcel of it, which is highly *impregnated* with the tinging body, by having had a greater quantity of the Saffron diffolv'd in a fmaller parcel of the liquor.

Now, though there may be fome particles of other tinging bodies that give a lovely Scarlet alfo, which though diluted never fo much with liquor, or looked on through never fo thin a parcel of ting'd liquor, will not yet afford a pale Yellow, but onely a kind of faint Red; yet this is no argument but that those ting dparticles may have in them the faintest degree of Yellow, though we may be unable to make them exhibit it; For that power of being diluted depending upon the divisibility of the ting'd body, if I am unable to make the tinging particles fo thin as to exhibit that colour, it does not therefore follow, that the thing is impoffible to be done; now, the tinging particles of fome bodies are of fuch a nature, that unlefs there be found fome way of comminuting them into lefs bulks then the liquor does difiolve them into, all the Rays that pass through them must neceffarily receive a tincture fo deep, as their appropriate refractions and bulks compar'd with the proprieties of the diffolving liquor must necessarily dispose them to empress, which may perhaps be a pretty deep Yellow, or pale Red.

And that this is not gratis dictum, I shall add one instance of this kind, wherein the thing is most manifest.

If you take Blue smalt, you shall find, that to afford the deepest Blue, which cæteris paribus has the greatest particles or fands; and if you further divide, or grind those particles on a Grindstone, or porphyry stone, you may by comminuting the fands of it, dilute the Blue into as pale a one. as you please, which you cannot do by laying the colour thin; for wherefoever any fingle particle is, it exhibits as deep a Blue as the whole mafs. Now, there are other Blues, which though never fo much ground, will not be diluted by grinding, becaufe confifting of very fmall particles, very deeply ting'd, they cannot by grinding be actually feparated into fmaller particles then the operation of the fire, or fome other diffolving menstruum, has reduc'd them to already. Thus all kind of Metalline colours, whether precipitated, sublim'd, calcin'd, or otherwife prepar'd, are hardly chang'd by grinding, as ultra marine is not more diluted; nor is Vermilion or Red-lead made of a more faint colour by grinding; for the smallest particles of these which I have view'd with my greatest Magnifying-Glass, if they be well enlightned, appear very deeply ting'd with their peculiar colours; nor, though I have magnified and enlightned the particles exceedingly, could I in many of them, perceive them to be transparent, or to be whole particles, but the fmallest specks that I could find among well ground Vermilion and Redlead, seem'd to be a Red mass, compounded of a multitude of less and less motes, which flicking together, compos'd a bulk, not one thousand thoufandth part of the smallest visible fand or mote. And

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And this I find generally in moft *Metalline* colours, that though they confift of parts fo exceedingly fmall, yet are they very deeply ting d, they being fo ponderous, and having fuch a multitude of terreftrial particles throng'd into a little room; fo that 'tis difficult to find any particle tranfparent or refembling a pretious ftone, though not impoffible; for I have obferv'd divers fuch fhining and refplendent colours intermixt with the particles of *Cinnaber*, both natural and artificial, before it hath been ground and broken or flaw'd into *Vermilion*: As I have alfo in *Orpiment*, *Red-lead*, and *Bife*, which makes me fuppofe, that those *metalline* colours are by grinding, not onely broken and feparated actually into fmaller pieces, but that they are alfo flaw'd and brufed ,whence they, for the moft part, become opacous, like flaw'd Cryftal or Glafs, *Sec.* But for *Smalts* and *verditures*, I have been able with a *Microfcope* to perceive their particles very many of them transparent.

Now, that the others also may be transparent, though they do not appear so to the *Microscope*, may be made probable by this Experiment : that if you take *ammel* that is almost *opacous*, and grind it very well on a *Porphyry*, or *Serpentine*, the small particles will by reason of their flaws, appear perfectly *opacous*; and that 'tis the flaws that produce this *opacous* from this, that particles of the same *Ammel* much thicker if unflaw'd will appear formewhat transparent even to the eye; and from this also, that the most transparent and clear Crystal, if heated in the fire, and then fuddenly quenched, so that it be all over flaw'd, will appear *opacous* and white.

And that the particles of *Metalline* colours are transparent, may be argued yet further from this, that the Crystals, or *Vitriols* of all Metals, are transparent, which fince they confist of *metalline* as well as *faline* particles, those *metalline* ones must be transparent, which is yet further confirm'd from this, that they have for the most part, *appropriate* colours; fo the *vitriol* of Gold is Yellow; of Copper, Blue, and fometimes Green; of Iron, green; of Tinn and Lead, a pale White; of Silver, a pale Blue, *O*.

And next, the Solution of all Metals into menstruums are much the same with the Vitriols, or Crystals. It seems therefore very probable, that those colours which are made by the precipitation of those particles out of the menstruums by transparent precipitating liquors should be transparent alfo. Thus Gold precipitates with oyl of Tartar, or spirit of Urine into a brown Yellow. Copper with spirit of Urine into a Mucous blue, which retains its transparency. A folution of sublimate (as the fame Illustrious Authour I lately mention'd shews in his 40. Experiment) precipitates with oyl of Tartar per deliquium, into an Orange colour'd precipitate; nor is it less probable, that the calcination of those Vitriols by the fire, should have their particles transparent: Thus Saccarum Saturni, or the Vitriol of Lead by calcination becomes a deep Orange-colour'd minium, which is a kind of precipitation by fome Salt which proceeds from the fire; common Vitriol calcin'd, yields a deep Brown Red, O.c. A third Argument, that the particles of Metals are transparent, is, that being calcin'd, and melted with Glass, they tinge the Glass with transparent

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And that the parts of Metals are transparent, may be farther argued from the transparency of Leaf-gold, which held against the light, both to the naked eye, and the *Microscope*, exhibits a deep Green. And though I have never seen the other Metals *laminated* so thin, that I was able to perceive them transparent, yet, for Copper and Brass, if we had the same conveniency for *laminating* them, as we have for Gold, we might, perhaps, through such plates or leaves, find very differing degrees of Blue, or Green; for it seems very probable, that those Rays that rebound from them ting'd, with a deep Yellow, or pale Red, as from Copper, or with a pale Yellow, as from Brass, have pass through them; for I cannot conceive how by reflection alone those Rays can receive a tincture, taking any *Hypothesis* extant.

So that we fee there may a fufficient reafon be drawn from thefe infrances, why those colours which we are unable to dilute to the palest Yellow, or Blue, or Green, are not therefore to be concluded not to be a deeper degree of them; for fuppoling we had a great company of fmall Globular effence Bottles, or roundGlafs bubbles, about the bignefs of aWalnut, fill'd each of them with a very deep mixture of Saffron, and that every one of them did appear of a deep Scarlet colour, and all of them together did exhibit at a distance, a deep dy'd Scarlet body. It does not follow, becaufe after we have come nearer to this congeries, or mafs, and divided it into its parts, and examining each of its parts feverally or apart, we find them to have much the fame colour with the whole mais; it does not, I fay, therefore follow, that if we could break those Globules fmaller, or any other ways come to fee a fmaller or thinner parcel of the ting'd liquor that fill'd those bubbles, that that ting'd liquor must always appear Red, or of a Scarlet hue, fince if Experiment be made, the quite contrary will enfue; for it is capable of being diluted into the paleft Yellow.

Now, that I might avoid all the Objections of this kind, by exhibiting an Experiment that might by ocular proof convince those whom other reasons would not prevail with, I provided me a Prismatical Glaß, made hollow, just in the form of a Wedge, such as is represented in the tenth Figure of the fixth scheme. The two parallelogram fides ABCD, ABEF, which met at a point, were made of the clearest Looking-glass plates well ground and polifh'd that I could get; these were joyn'd with hard cement to the triangular fides, BCE, ADF, which were of Wood; the Parallelogram base BCEF, likewife was of Wood joyn'd on to the rest with hard cement, and the whole Prismatical Box was exactly ftopt every where, but onely a little hole near the bafe was left, whereby the Veffel could be fill'd with any liquor, or emptied again at pleafure. One of these Boxes (for I had two of them) I fill'd with a pretty deep tincture of Aloes, drawn onely with fair Water, and then stopt the hole with a piece of Wax, then, by holding this Wedge against the Light, and looking through it, it was obvious enough to fee the tincture of the liquor near the edge of the Wedge where it was but very thin, to be a pale but M well

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well colour'd Yellow, and further and further from the edge, as the liquor grew thicker and thicker, this tincture appear'd deeper and deeper, so that near the blunt end, which was seven Inches from the edge and three Inches and an half thick; it was of a deep and well colour'd Red. Now, the clearer and purer this tincture be, the more lovely will the deep Scarlet be, and the fouler the tincture be, the more dirty will the Red appear; so that some dirty tinctures have afforded their deepest Red much of the colour of burnt Oker or Spanish brown; others as lovely a colour as Vermilion, and fome much brighter; but feveral others, according as the tinctures were worfe or more foul, exhibited various kinds of Reds, of very differing degrees.

The other of these Wedges, I fill'd with a most lovely tincture of Copper, drawn from the filings of it, with spirit of Urine, and this Wedge held as the former against the Light, afforded all manner of Blues, from the fainteft to the deepeft, fo that I was in good hope by thele two, to have produc'd all the varieties of colours imaginable; for I thought by this means to have been able by placing the two Parallelogram fides together, and the edges contrary ways, to have fo mov'd them to and fro one by another, as by looking through them in feveral places, and through feveralthickneffes, I fhould have compounded, and confequently have feen all those colours, which by other like compositions of colours would have enfued.

But infteed of meeting with what I look'd for, I met with fomewhat more admirable; and that was, that I found my felf utterly unable to fee through them when placed both together, though they were transparent enough when afunder ; and though I could fee through twice the thicknefs, when both of them were fill'd with the fame colour'd liquors, whether both with the Yellow, or both with the Blue, yet when one was fill'd with the Yellow, the other with the Blue, and both looked through, they both appear'd dark, onely when the parts near the tops were look'd through, they exhibited Greens, and those of very great variety, as I expected, but the Purples and other colours, I could not by any means make, whether I endeavour'd to look through them both against the Sun, or whether I plac'd them against the hole of a darkned room.

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But notwithstanding this mis-ghessing, I proceeded on with my trial in a dark room, and having two holes near one another, I was able, by placing my Wedges against them to mix the ting'd Rays that past through them, and fell on a sheet of white Paper held at a convenient distance from them as I pleas'd; fo that I could make the Paper appear of what colour I would, by varying the thickneffes of the Wedges, and confequently the tincture of the Rays that past through the two holes, and sometimes also by varying the Paper, that is, insteed of a white Paper, holding a gray, or a black piece of Paper.

Whence I experimentally found what I had before imagin'd, that all the varieties of colours imaginable are produc'd from several degrees of these two colours, namely, Yellow and Blue, or the mixture of them with light and darkness, that is, white and black. And all those almost infinite varieties which Limners and Painters are able to make by compounding

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pounding those feveral colours they lay on their Shels or Palads, are nothing elfe, but some compositum, made up of some one or more, or all of these four.

Now, whereas it may here again be objected, that neither can the Reds be made out of the Yellows, added together, or laid on in greater or lefs quantity, nor can the Yellows be made out of the Reds though laid never fo thin; and as for the addition of White or Black, they do nothing but either whiten or darken the colours to which they are added, and not at all make them of any other kind of colour: as for inftance, *Vermilion*, by being temper'd with White Lead, does not at all grow more Yellow, but onely there is made a whiter kind of Red. Nor does Yellow *Oker*, though laid never fo thick, produce the colour of *Vermilion*, nor though it be temper'd with Black, does it at all make a Red; nay, though it be temper'd with Black, does it at all make a Red; nay, though it be temper'd with White, it will not afford a fainter kind of Yellow, fuch as *mafficut*, but onely a whiten'd Yellow; nor will the Blues be *diluted* or deepned after the manner I fpeak of, as *Indico* will never afford fo fine a Blue as *Oltramarine* or *Bife*; nor will it, temper'd with *Vermilion*, 'ever afford a Green, though each of them be never fo much temper'd with white.

To which I answer, that there is a great difference between *diluting* a colour and whitening of it; for *diluting* a colour, is to make the colour'd parts more thin, fo that the ting'd light, which is made by trajecting those ting'd bodies, does not receive to deep a tincture; but white ning a colour is onely an intermixing of many clear reflections of light among the fame ting'd parts; deepning allo, and darkning or blacking a colour, are very different; for deepning a colour, is to make the light pass through a greater quantity of the fame tinging body; and darkning or blacking a colour, is onely interposing a multitude of dark or black fpots among the fame ting'd parts, or placing the colour in a more faint light.

First therefore, as to the former of these operations, that is, diluting and deepning, most of the colours us'd by the Limners and Painters are incapable of, to wit, Vermilion and Red-lead, and Oker, becaufe the ting'd parts are fo exceeding fmall, that the most curious Grindstones we have, are not able to feparate them into parts actually divided fo fmall as the ting'd particles are; for looking on the most curiously ground Vermilion, and Oker, and Red-lead, I could perceive that even those fmall corpufcles of the bodies they left were compounded of many pieces, that is, they feem'd to be fmall pieces compounded of a multitude of leffer ting'd parts : each piece feeming almost like a piece of Red Glass, or ting'd Crystal all flaw'd; fo that unless the Grindstone could actually divide them into fmaller pieces then those flaw'd particles were, which compounded that ting'd mote I could fee with my Microfcope, it would be impoffible to dilute the colour by grinding, which, because the finest we have will not reach to do in Vermilion or Oker, therefore they cannot at the Atterofeage are plainly enough to be all, or very hardly be diluted. Other colours indeed, whose ting'd particles are such as may be made imaller, by grinding their colour, may be diluted. Thus feveral of the sould whitend. 01111 M 2

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Blues may be diluted, as Smalt and Bife; and Mafticut, which is Yellow, may be made more faint: And even Vermilion it felf may, by too much grinding, be brought to the colour of Red-lead, which is but an Orange colour, which is confeft by all to be very much upon the Yellow. Now, though perhaps fomewhat of this diluting of Vermilion by overmuch grinding may be attributed to the Grindstone, or muller, for that fome of their parts may be worn off and mixt with the colour, yet there feems not very much, for I have done it on a Serpentine-stone with a muller made of a Pebble, and yet observ'd the fame effect follow.

And fecondly, as to the other of these operations on colours, that is, the deepning of them, Limners and Painters colours are for the most part also uncapable. For they being for the most part *opacous*; and that *opacouss*, as I faid before, proceeding from the particles, being very much flaw'd, unless we were able to joyn and re-unite those flaw'd particles again into one piece, we shall not be able to deepen the colour, which fince we are unable to do with most of the colours which are by Painters accounted *opacous*, we are therefore unable to deepen them by adding more of the fame kind.

But becaufe all those opacous colours have two kinds of beams or Rays reflected from them, that is, Rays unting d, which are onely reflected from the outward furface, without at all penetrating of the body, and ting'd Rays which are reflected from the inward furfaces or flaws after they have fuffer'd a two-fold refraction; and becaufe that transparent liquors mixt with fuch corpufcles, do, for the most part, take off the former kind of reflection; therefore these colours mixt with Water or Oyl, appear much deeper than when dry, for most part of that white reflection from the outward furface is remov'd. Nay, fome of these colours are very much deepned by the mixture with fome transparent liquor, and that because they may perhaps get between those two flaws, and so consequently joyn two or more of those flaw'd pieces together; but this happens but in a very few.

Now, to fhew that all this is not gratis dictum, I shall set down some Experiments which do manifest these things to be probable and likely, which I have here deliver'd.

For, first, if you take any ting'd liquor whatfoever, especially if it be pretty deeply ting'd, and by any means work it into a froth, the congeries of that froth shall seem an opacous body, and appear of the same colour, but much whiter than that of the liquor out of which it is made. For the abundance of reflections of the Rays against those furfaces of the bubbles of which the froth consists, does so often rebound the Rays backwards, that little or no light can pass through, and consequently the froth appears opacous. Again, if to any of these ting'd liquors that will endure the boiling there be added a small quantity of fine flower (the parts of which through the Microscope are plainly enough to be perceiv'd to consist of transparent corpuscies) and suffer'd to boyl till it thicken the liquor, the mass of the liquor will appear opacous, and ting'd with the fame colour, but very much whiten'd.

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Thus, if you take a piece of transparent Glass that is well colour'd, and by heating it, and then quenching it in Water, you flaw it all over, it will become *opacous*, and will exhibit the same colour with which the piece is ting'd, but fainter and whiter.

Or, if you take a Pipe of this transparent Glass, and in the flame of a Lamp melt it, and then blow it into very thin bubbles, then break those bubbles, and collect a good parcel of those *lamine* together in a Paper, you shall find that a small thickness of those Plates will constitute an *opacons* body, and that you may see through the mass of Glass before it be thus *laminated*, above four times the thickness: And besides, they will now afford a colour by reflection as other *opacous* (as they are call'd) colours will, but much fainter and whiter than that of the Lump or Pipe out of which they were made.

Thus alfo, if you take *Putty*, and melt it with any transparent colour'd Glas, it will make it become an *opacous* colour'd lump, and to yield a paler and whiter colour than the lump by reflection.

The fame thing may be done by a preparation of Antimony, as has been fhewn by the Learned Physician, D^{r.} C. M. in his Excellent Observations and Notes on Nery's Art of Glass; and by this means all transparent colours become opacous, or animels. And though by being ground they lofe very much of their colour, growing much whiter by reason of the multitude of fingle reflections from their outward furface, as I shew'd afore, yet the fire that in the nealing or melting re-unites them, and so renews those ffurious reflections, removes also those whitenings of the colour that proceed from them.

As for the other colours which Painters use, which are transparent, and us'd to varnish over all other paintintings, 'tis well enough known that the laying on of them thinner or thicker, does very much *dilute* or deepen their colour.

Painters Colours therefore confifting most of them of folid particles, fo fmall that they cannot be either re-united into thicker particles by any Art yet known, and confequently cannot be deepned; or divided into particles fo fmall as the flaw'd particles that exhibit that colour, much lefs into fmaller, and confequently cannot be diluted; It is neceffary that they which are to imitate all kinds of colours, should have as many degrees of each colour as can be procur'd. And to this purpose, both Limners and Painters have a very great variety both of Yellows and Blues, befides feveral other colour'd bodies that exhibit very compounded colours, fuch as Greens and Purples; and others that are compounded of feveral degrees of Yellow, or feveral degrees of Blue, fometimes unmixt, and fometimes compounded with feveral other colour'd bodies. The Yellows, from the paleft to the deepeft Red or Scarlet, which has no intermixture of Blue, are pale and deep Masticut, Orpament, English Oker, brown Oker, Red Lead, and Vermilion, burnt English Oker, and burnt brown Oker, which last have a mixture of dark or dirty parts with them, O.c. make ute of are fuch, char they make many transfor

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Their Blues are feveral kinds of *smalts*, and *Verditures*, and *Bife*, and *Ultramarine*, and *Indico*, which laft has many dirty or dark parts intermixt with it.

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Their compounded colour'd bodies, as *Pink*, and *Verdigrefe*, which are Greens, the one a *Popingay*, the other a *Sea-green*; then *Lac*, which is a very lovely *Purple*.

To which may be added their Black and White, which they also ufually call Colours, of each of which they have feveral kinds, fuch as Bone Black, made of Ivory burnt in a close Veffel, and Blue Black, made of the small coal of Willow, or some other Wood; and Cullens earth, which is a kind of brown Black, O.c. Their usual Whites are either artificial or natural White Lead, the last of which is the best they yet have, and with the mixing and tempering these colours together, are they able to make an imitation of any colour whatfoever: Their Reds or deep Yellows, they can dilute by mixing pale Yellows with them, and deepen their pale by mixing deeper with them; for it is not with Opacous colours as it is with transparent, where by adding more Yellow to yellow, it is deepned, but in opacous diluted. They can whiten any colour by mixing White with it, and darken any colour by mixing Black, or fome dark and dirty colour. And in a word, most of the colours, or colour'd bodies they use in Limning and Painting, are such, as though mixt with any other of their colours, they preferve their own hue, and by being in fuch very smal parts dispers'd through the other colour'd bodies, they both, or altogether reprefent to the eye a compositum of all; the eye being unable, by reafon of their fmalnefs, to diftinguish the peculiarly colour'd particles, but receives them as one intire compositum : whereas in many of these, the Microscope very eafily distinguishes each of the compounding colours diffinct, and exhibiting its own colour.

Thus have I by gently mixing Vermilion and Bife dry, produc'd a very fine Purple, or mixt colour, but looking on it with the Microfcope, I could eafily diftinguish both the Red and the Blue particles, which did not at all produce the Phantasm of Purple.

To fumm up all therefore in a word, I have not yet found any folid colour d body, that I have yet examin'd, perfectly opacous; but those that are leaft transparent are Metalline and Mineral bodies, whose particles generally, feeming either to be very fmall, or very much flaw'd, appear for the most part opacous, though there are very few of them that I have look'd on with a Microscope, that have not very plainly or circumstantithat exhibit yery compounded ally manifested themselves transparent. - And indeed, there feem to be fo few bodies in the world that are in minimis opacous, that I think one may make it a rational Query, Whether there be any body absolutely thus opacous? For I doubt not at all (and I have taken notice of very many circumstances that make me of this mind) that could we very much improve the Microscope, we might be able to fee all those bodies very plainly transparent, which we now are fain onely to ghefs at by circumstances. Nay, the Object Glasses we yet make use of are such, that they make many transparent bodies to the eye, 1 near

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eye, feem opacous through them, which if we widen the Aperture a little, and caft more light on the objects, and not charge the Glaffes fo deep, will again difclose their transparency.

Now, as for all kinds of colours that are diffolvable in Water, or other liquors, there is nothing fo manifeft, as that all those ting'd liquors are transparent; and many of them are capable of being *dilated* and compounded or mixt with other colours, and divers of them are capable of being very much chang'd and heightned, and fixt with feveral kinds of *Saline menstruums*. Others of them upon compounding, deftroy or vitiate each others colours, and *precipitate*, or otherwise very much alter each others tincture. In the true ordering and *dilating*, and deepning, and mixing, and fixing of each of which, confists one of the greatest myfteries of the Dyers; of which particulars, because our *Microscope* affords us very little information, I shall add nothing more at present; but onely that with a very few tinctures order'd and mixt after certain ways, too long to be here fet down, I have been able to make an appearance of all the various colours imaginable, without at all using the help of *salts*, or *Saline menstruums* to vary them.

As for the mutation of Colours by *Saline menftruums*, they have already been fo fully and excellently handled by the lately mention'd Incomparable *Anthomr*, that I can add nothing, but that of a multitude of trials that I made, I have found them exactly to agree with his Rules and Theories; and though there may be infinite infrances, yet may they be reduc'd under a few Heads, and compris'd within a very few Rules. And generally I find, that *Saline menftruums* are most operative upon those colours that are Purple, or have fome degree of Purple in them, and upon the other colours much lefs. The *fpurious* pulfes that compose which, being (as I formerly noted) to very neer the middle between the true ones, that a fmall variation throws them both to one fide, or both to the other, and so confequently must make a vast mutation in the formerly appearing Colour.

Observ. XI. Of Figures observ'd in small Sand.

SAnd generally feems to be nothing elfe but exceeding fmall Pebbles, or at leaft fome very fmall parcels of a bigger ftone; the whiter kind feems through the *Microfcope* to confift of fmall transparent pieces of fome *pellucid* body, each of them looking much like a piece of *Alum*, or *salt Gem*; and this kind of Sand is angled for the most part irregularly, without any certain fhape, and the granules of it are for the most part flaw d, though amongst many of them it is not difficult to find fome that are perfectly *pellucid*, like a piece of clear Crystal, and divers likewife most curiously fhap'd, much after the manner of the bigger *Stiriæ* of Crystal, or like the fmall Diamants I observ'd in certain Flints, of which I shall by and by relate; which last particular feems to argue, that this kind of Sand is not made

made by the comminution of greater transparent Crystaline bodies, but by the concretion or coagulation of Water, or some other fluid body.

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There are other kinds of courfer Sands, which are browner, and have their particles much bigger; thefe, view'd with a *Microfcope*, feem much courfer and more *opacous* fubftances, and most of them are of some irregularly rounded Figures; and though they feem not so *opacous* as to the naked eye, yet they feem very foul and cloudy, but neither do these want curiously transparent, no more than they do regularly figur'd and well colour'd particles, as I have often found.

There are multitudes of other kinds of Sands, which in many particulars, plainly enough difcoverable by the *Microfcope*, differ both from thefe laft mention'd kinds of Sands, and from one another: there feeming to be as great variety of Sands, as there is of Stones. And as amongft Stones fome are call'd precious from their excellency, fo alfo are there Sands which deferve the fame Epithite for their beauty; for viewing a fmall parcel of *Eaft-India* Sand (which was given me by my highly honoured friend, Mr. *Daniel Colwall*) and, fince that, another parcel, much of the fame kind, I found feveral of them, both very transparent like precious Stones, and regularly figur'd like Crystal, *Cornifh* Diamants, fome Rubies, *Oc.* and alfo ting'd with very lively and deep colours, like *Rubys, Saphyrs, Emeralds*, &c. Thefe kinds of granuls I have often found alfo in *Englifh* Sand. And 'tis eafie to make fuch a counterfeit Sand with deeply ting'd Glafs, Enamels and Painters colours.

It were endless to describe the multitudes of Figures I have met with in these kind of minute bodies, such as *Spherical,Oval,Pyramidal, Conical*, *Prismatical*, of each of which kinds I have taken notice.

But amongst many others, I met with none more observable than this pretty Shell (defcribed in the Figure X. of the fifth scheme) which, though as it was light on by chance, deferv'd to have been omitted (I being unable to direct any one to find the like) yet for its rarity was it not inconfiderable, efpecially upon the account of the information it may afford us. For by it we have a very good inftance of the curiofity of Nature in another kind of Animals which are removid, by reason of their minuteness, beyond the reach of our eyes; so that as there are several forts of Infects, as Mites, and others, fo fmall as not yet to have had any names; (fome of which I shall afterwards describe) and small Fishes, as Leeches in Vineger; and fmal vegetables, as Mofs, and Rofe-Leave-plants; and fmall Mufhroms, as mould : fo are there, it feems, fmall Shel-fifh likewile, Nature shewing her curiofity in every Tribe of Animals, Vegetables, and Minerals. I was trying feveral fmall and fingle Magnifying Glaffes, and cafually viewing a parcel of white Sand, when I perceiv'd one of the grains exactly shap'd and wreath'd like a Shell, but endeavouring to diffinguish it with my naked eye, it was fo very fmall, that I was fain again to make use of the Glass to find it; then, whileft I thus look'd on it, with a Pin I separated all the reft of the granules of Sand, and found it afterwards to appear to the naked eye an exceeding small white spot, no bigger than the point of a Pin.

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Pin. Afterwards I view'd it every way with a better Microfeope, and found it on both fides, and edge-ways, to refemble the Shell of a fmall Waters Snail with a flat fpiral Shell: it had twelve wreathings, a, b, c, d, e, &c. all very proportionably growing one lefs than another toward the middle or center of the Shell, where there was a very fmall round white fpot. I could not certainly difcover whether the Shell were hollow or not, but it feem'd fill'd with fomewhat, and 'tis probable that it might be petrify'd as other larger Shels often are, fuch as are mention'd in the feventeenth Obfervation.

Observ. XII. Of Gravel in Urine.

Have often observ'd the Sand or Gravel of Urine, which seems to be a tartareous substance, generated out of a saline and a terrestrial substance crystalliz'd together, in the form of Tartar, sometimes sticking to the fides of the Vrinal, but for the most part finking to the bottom, and there lying in the form of coorse common Sand; these, through the Microscope, appear to be a company of small bodies, partly transparent, and partly opacous, some White, some Yellow, some Red, others of more brown and duskie colours.

The Figure of them is for the most part flat, in the manner of Slats, or fuch like plated Stones, that is, each of them seem to be made up of several other thinner Plates, much like *Muscovie Glass*, or *English Sparr*, to the last of which, the white plated Gravel seems most likely; for they seem not onely plated like that, but their sides shap'd also into *Rhombs*, *Rhomboeids*, and sometimes into *Rest angles* and *squares*. Their bigness and Figure may be seen in the second *Figure* of the fixth *Plate*, which represents about a dozen of them lying upon a plate A BCD, some of which, as a, b, c, d, seem'd more regular than the rest, and e, which was a small one, sticking on the top of another, was a perfect *Rhomboeid* on the top, and had four *Rest angular* fides.

The line E which was the measure of the Microscope, is 3 part of an English Inch, fo that the greatest bredth of any of them, exceeded not the part of an Inch. Putting these into several liquors, I found Oyl of Vitriel, Spirit of Urine, and several other Saline menstruums to disolve them; and the first of these in less than a minute without Ebullition, Water, and several other liquors, had no sudden operation upon them. This I mention, because those liquors that disolve them, first make them very white, not vitiating, but rather rectifying their Figure, and thereby make them afford a very pretty object for the Microscope. How great an advantage it would be to such as are troubled with the Stone, to find some menstruum that might dissolve them without hurting the Bladder, is easily imagin'd, fince some injections made of such bodies might likewise dissolve the stone, which seems much of the fame nature.

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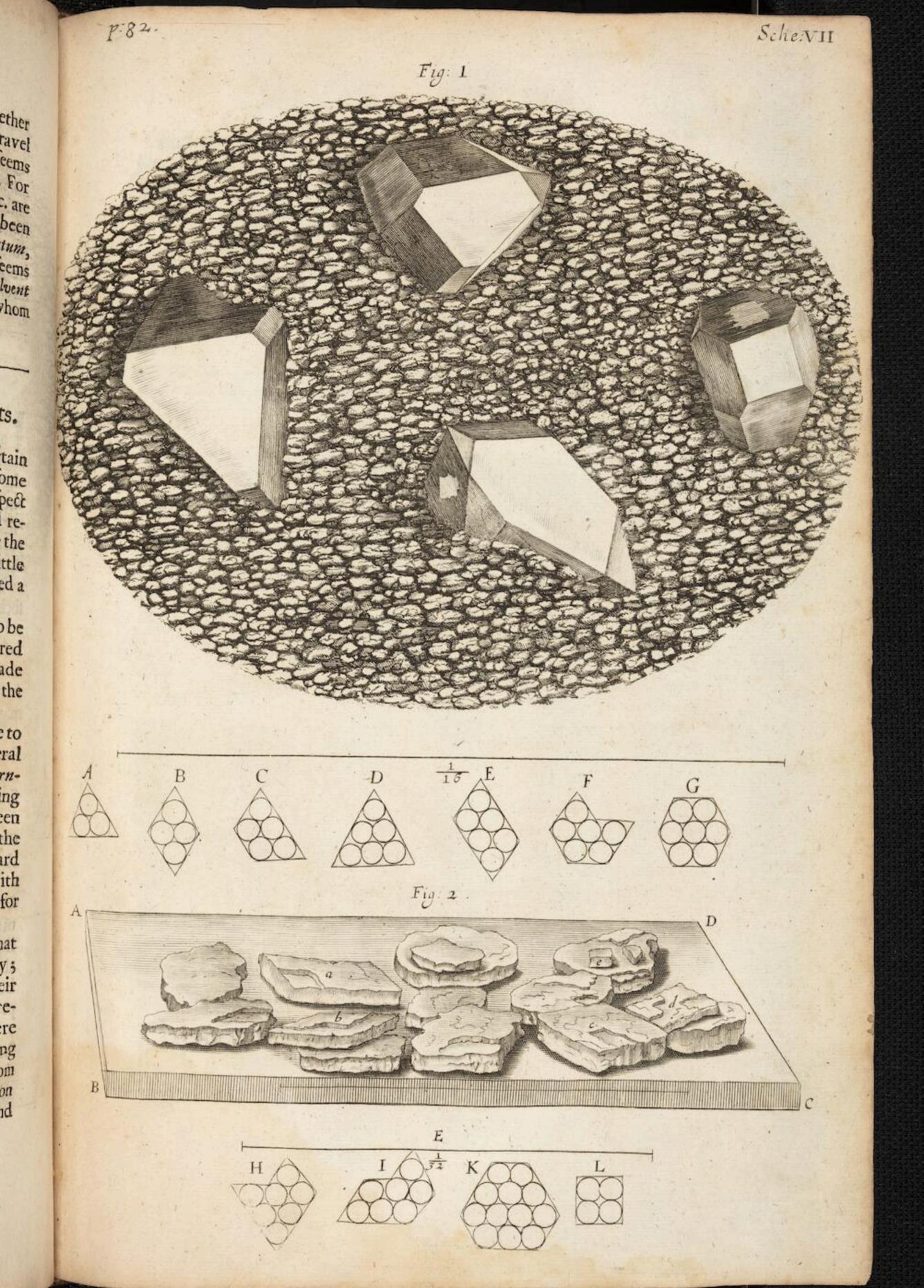
It may therefore, perhaps, be worthy fome Phyficians enquiry, whether there may not be fomething mixt with the Urine in which the Gravel or Stone lies, which may again make it diffolve it, the first of which feems by it's regular Figures to have been fometimes *Crystalliz'd* out of it. For whether this *Crystallization* be made in the manner as *Alum*, *Peter*,&c. are *crystallized* out of a cooling liquor, in which, by boyling they have been dinolv'd; or whether it be made in the manner of *Tartarum Vitriolatum*, that is, by the *Coalition* of an *acid* and a *sulphureous* fubstance, it feems not impossible, but that the liquor it lies in, may be again made a *disfolvent* of it. But leaving thefe inquiries to Physicians or Chymists, to whom it does more properly belong, I shall proceed.

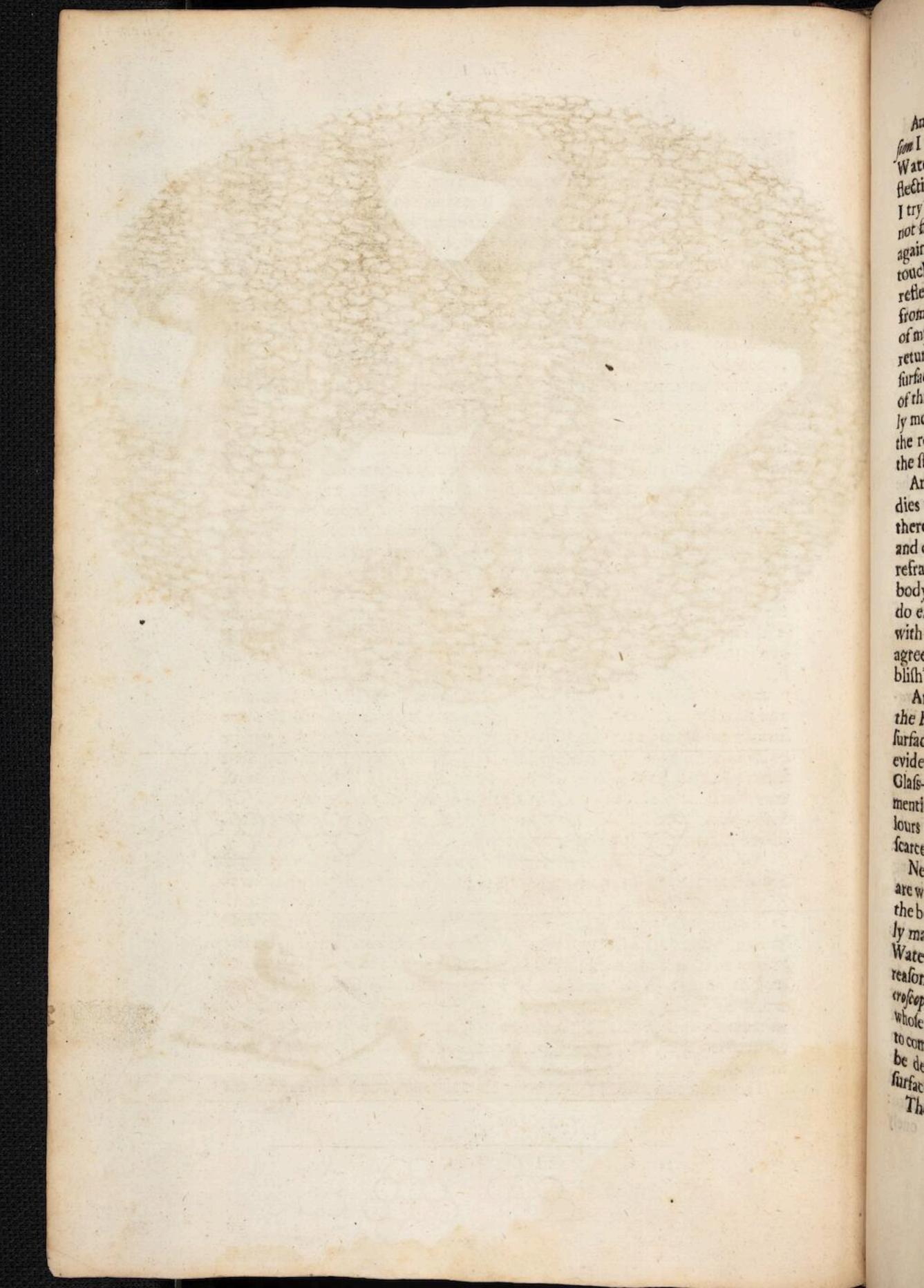
Observ. XIII. Of the small Diamants, or Sparks in Flints.

Chancing to break a Flint stone in pieces, I found within it a certain cavity all crusted over with a very pretty candied substance, some of the parts of which, upon changing the posture of the Stone, in respect of the *Incident* light, exhibited a number of small, but very vivid reflections; and having made use of my *Microscope*, I could perceive the whole surface of that cavity to be all beset with a multitude of little *Crystaline* or *Adamantine* bodies, so curiously shap'd, that it afforded a not unpleasing object.

Having confidered those vivid repercussions of light, I found them to be made partly from the plain external furface of these regularly figured bodies (which afforded the vivid reflections) and partly to be made from within the somewhat *pellucid* body, that is, from some furface of the body, opposite to that superficies of it which was next the eye.

And because these bodies were so small, that I could not well come to make Experiments and Examinations of them, I provided me feveral small stiriæ of Crystals or Diamants, found in great quantities in Cornwall and are therefore commonly called Cornifh Diamants: these being very pellucid, and growing in a hollow cavity of a Rock (as I have been feveral times informed by those that have observ'd them) much after the fame manner as these do in the Flint; and having besides their outward. furface very regularly shap'd, retaining very near the same Figures with fome of those I observ'd in the other, became a convenient help to me for the Examination of the proprieties of those kinds of bodies. And first for the Reflections; in these I found it very observable, That the brightest reflections of light proceeded from within the pellucid body; that is, that the Rays admitted through the pellucid fubstance in their getting out on the opposite fide, were by the contiguous and strong reflecting furface of the Air very vividly reflected, fo that more Rays were reflected to the eye by this furface, though the Ray in entring and getting out of the Crystal had fuffer'd a double refraction, than there were from the outward furface of the Glafs where the Ray had fuffer'd no reflraction at all. And





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And that this was the furface of the Air that gave fo vivid a re-perenffion I try'd by this means. I funk half of a ftiria in Water, fo that only Water was contiguous to the under furface, and then the internal reflection was fo exceedingly faint, that it was fcarce difcernable. Again, I try'd to alter this vivid reflection by keeping off the Air, with a body not fluid, and that was by rubbing and holding my finger very hard against the under surface, so as in many places the pulp of my finger did touch the Glafs, without any interjacent air between; then observing the reflection, I found, that wherefoever my finger or fkin toucht the furface, from that part there was no reflection, but in the little furrows or creafes of my fkin, where there remain d little fmall lines of air, from them was return'd a very vivid reflection as before. I try'd further, by making the furface of very pure Quickfilver to be contiguous to the under furface of this pellucid body, and then the reflection from that was fo exceedingly more vivid than from the air, as the reflection from air was than the reflection from the Water; from all which trials I plainly faw, that the ftrong reflecting air was the caufe of this Phanomenon.

And this agrees very well with the Hypothesis of light and Pellucid bodies which I have mention'd in the description of Muscovy-glass; for we there suppose Glass to be a medium, which does less result the pulse of light, and consequently, that most of the Rays incident on it enter into it, and are refracted towards the perpendicular; whereas the air I suppose to be a body that does more result it, and consequently more are re-percuss'd then do enter it: the same kind of trials have I made, with Crystalline Glass, with drops of fluid bodies, and several other ways, which do all seem to agree very exactly with this Theory. So that from this Principle well establish'd, we may deduce several Corollaries not unworthy observation.

And the first is, that it plainly appears by this, that the production of the Rainbow is as much to be afcribed to the reflection of the concave furface of the air, as to the refraction of the Globular drops : this will be evidently manifest by these Experiments, if you foliate that part of a Glass-ball that is to reflect an Iris, as in the Cartesian Experiment, above mention'd, the reflections will be abundantly more ftrong, and the colours more vivid : and if that part of the furface be touch'd with Water, fcarce affords any fenfible colour at all. Next we learn, that the great reafon why pellacid bodies beaten fmall are white, is from the multitude of reflections, not from the particles of the body, but from the contiguous furface of the air. And this is evidently manifested, by filling the Interstitia of those powder'd bodies with Water, whereby their whiteness prefently disappears. From the same reason proceeds the whiteness of many kinds of Sands, which in the Microscope appear to be made up of a multitude of little pellucid bodies, whole brighteft reflections may by the Microfcope be plainly perceived to come from their internal furfaces; and much of the whitenels of it may be deftroy'd by the affusion of fair Water to be contiguous to those lurfaces. reatile than what I have fliged, and perhaps than

The whiteness also of froth, is for the most part to be ascribed to the N 2 reflection

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reflection of the light from the furface of the air within the Bubbles, and very little to the reflection from the furface of the Water it felf: for this laft reflection does not return a quarter fo many Rays, as that which is made from the furface of the air, as I have certainly found by a multitude of Observations and Experiments.

The whitenefs of Linnen, Paper, Silk, &c. proceeds much from the fame reason, as the Microscope will easily discover; for the Paper is made up of an abundance of pellucid bodies, which afford a very plentifull reflection from within, that is, from the concave surface of the air contiguous to its component particles; wherefore by the affusion of Water, Oyl, Tallow, Turpentine, Oc. all those reflections are made more faint, and the beams of light are suffer'd to traject & run through the Paper more freely.

Hence further we may learn the reafon of the whitenefs of many bodies, and by what means they may be in part made *pellucid*: As white Marble for inftance, for this body is composed of a *pellucid* body exceedingly flaw'd, that is, there are abundance of thin, and very fine cracks or chinks amongst the multitude of particles of the body, that contain in them small parcels of air, which do fo *re-percuss* and drive back the penetrating beams, that they cannot enter very deep within that body, which the *Microscope* does plainly inform us to be made up of a *Congeries* of *pellucid* particles. And I further found it fomewhat more evidently by fome attempts I made towards the making transparent Marble, for by heating the Stone a little, and foaking it in Oyl, Turpentine, Oyl of Turpentine, \mathcal{C}_c , I found that I was able to fee much deeper into the body of Marble then before; and one trial, which was not with an uncruous substance, succeeded better than the rest, of which, when I have a better opportunity, I shall make further trial.

This also gives us a probable reason of the fo much admired Phanomena of the Oculus Mundi, an Oval stone, which commonly looks like white Alabaster, but being laid a certain time in Water, it grows pellucid, and transparent, and being fuffer'd to lie again dry, it by degrees loses that transparency, and becomes white as before. For the Stone being of a hollow spongie nature, has in the first and last of these appearances, all those pores fill'd with the obtunding and reflecting air; whereas in the fecond, all those pores are fill'd with a medium that has much the fame refraction with the particles of the Stone, and therefore those two being contiguous, make, as 'twere, one continued medium, of which more is faid in the 15. Observation. the body, but from the contronous furface of There are a multitude of other Phanomena, that are produc'd from this fame Principle, which as it has not been taken notice of by any yet that I know, fo I think, upon more diligent observation, will it not be found the least confiderable. But I have here onely time to hint Hypotheses, and not to profecute them fo fully as I could wifh; many of them having a valt extent in the production of a multitude of Phanomena, which have been by others, either not attempted to be explain'd, or elfe attributed to some other cause than what I have affign'd, and perhaps than the right; and therefore I shall leave this to the profecution of fuch as have more leifure : reffection onely

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onely before I leave it, I must not pretermit to hint, that by this Principle, multitudes of the Phanomena of the air, as about Mifts, Clouds, Meteors, Haloes,&c. are most plainly and (perhaps) truly explicable; multitudes also of the Phanomena in colour'd bodies, as liquors, O.c. are dehomborid, as F. or an Hex-angular Frenze, as h ducible from it.

And from this I shall proceed to a second confiderable Phanomenon which these Diamants exhibit, and that is the regularity of their Figure, which is a propriety not lefs general than the former 3 It comprising within its extent, all kinds of Metals, all kinds of Minerals, most Precious stones, all kinds of salts, multitudes of Earths, and almost all kinds of fluid bodies. And this is another propiety, which, though a little fuperficially taken notice of by fome, has not, that I know, been fo much as attempted to be explicated by any.

This propriety of bodies, as I think it the most worthy, and next in order to be confider'd after the contemplation of the Globular Figure, fo have I long had a defire as wel as a determination to have profecuted it if I had had an opportunity, having long fince propos'd to my felf the method of my enquiry therein, it containing all the allurements that I think any enquiry is capable of: For, first I take it to proceed from the most simple principle that any kind of form can come from, next the Globular, which was therefore the first I set upon, and what I have therein perform'd, I leave the Judicious Reader to determine. For as that form proceeded from a propiety of fluid bodies, which I have call'd Congruity, or Incongruity; fo I think, had I time and opportunity, I could make probable, that all these regular Figures that are so confpicuoully various and curious, and do fo adorn and beautifie fuch multitudes of bodies, as I have above hinted, arife onely from three or four feveral politions or poltures of Globular particles, and those the most plain, obvious, and necessary conjunctions of fuch figur'd particles that are poffible, fo that fuppoling fuch and fuch plain and obvious caufes concurring the coagulating particles must necessarily compose a body of such a determinate regular Figure, and no other; and this with as much neceffity and obviousness as a fluid body encompast with a Heterogeneous fluid must be protruded into a spherule or Globe. And this I have ad oculum demonstrated with a company of bullets, and fome few other very fimple bodies; fo that there was not any regular Figure, which I have hitherto met withall, of any of those bodies that I have above named, that I could not with the composition of bullets or globules, and one or two other bodies, imitate, even almost by shaking them together. And thus for instance may we find that the Globular bullets will of themfelves, if put on an inclining plain, fo that they may run together, naturally run into a triangular order, composing all the variety of figures that can be imagin'd to be made out of aquilateral triangles; and fuch will you find, upon trial, all the furfaces of Alum to be compos'd of: For three bullets lying on a plain, as close to one another as they can compose an aquilatero-triangular form, as in A in the 7. Scheme. If a fourth be joyn'd to them on either fide as closely as it can, they tour compose the most regular Rhombus consisting of two aquilateral triangles, evinity.

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as B. If a fifth be joyn'd to them on either fide in as close a polition as it can, which is the propriety of the Texture, it makes a Trapezium, or fourfided Figure, two of whose angles are 120. and two 60. degrees, as C. If a fixth be added, as before, either it makes an equilateral triangle, as D, or a Rhomboeid, as E, or an Hex-angular Figure, as F, which is compos'd of two primary Rhombes. If a feventh be added, it makes either an æquilatero-hexagonal Figure, as G, or fome kind of fix-fided Figure, as H, or I. And though there be never fo many placed together, they may be rang'd into fome of these lately mentioned Figures, all the angles of which will be either 60. degrees, or 120. as the figure K. which is an aquiangular hexagonal Figure is compounded of 12. Globules, or may be of 25, or 27, or 36, or 42, O.c. and by these kinds of texture, or position of globular bodies, may you find out all the variety of regular shapes, into which the smooth surfaces of Alum are form'd, as upon examination any one may eafily find; nor does it hold only in superficies, but in folidity alfo, for it's obvious that a fourth Globule laid upon the third in this texture, composes a regular Tetrahedron, which is a very usual Figure of the Crystals of Alum. And (to haften) there is no one Figure into which Alum is observed to be crystallized, but may by this texture of Globules be imitated, and by no other.

I could inftance also in the Figure of Sea-falt, and Sal-gem, that it is compos'd of a texture of Globules, placed in a cubical form, as L, and that all the Figures of those Salts may be imitated by this texture of Globules, and by no other what so ever. And that the forms of Vitriol and of Salt-Peter, as also of Crystal, Hore-frost, &cc. are compounded of these two textures, but modulated by certain proprieties: But I have not here time to infift upon, as I have not neither to thew by what means Globules come to be thus context, and what those Globules are, and many other particulars requisite to a full and intelligible explication of this propriety of bodies. Nor have I hitherto found indeed an opportunity of profecuting the inquiry fo farr as I defign'd; nor do I know when I may, it requiring abundance of time, and a great deal of affistance to go through with what I defign'd; the model of which was this:

First, to get as exact and full a collection as I could, of all the differing kinds of Geometrical figur'd bodies, some three or sour several bodies of each kind.

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Secondly, with them to get as exact a Hiftory as poffibly I could learn of their places of Generation or finding, and to enquire after as many circumstances that tended to the Illustrating of this Enquiry, as poffibly I could observe.

Thirdly, to make as many trials as upon experience I could find requifite, in Diffolutions and Coagulations of feveral crystallizing Salts; for the needfull instruction and information in this Enquiry.

Fourthly, to make feveral trials on divers other bodies, as Metals, Minerals, and Stones, by diffolving them in feveral *Menftruums*, and crystalizing them, to fee what Figures would arife from those feveral *Compositums*.

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Fitfthly, to make Compositions and Coagulations of feveral Salts together into the fame mass, to observe of what Figure the product of them would be; and in all, to note as many circumstances as I should judge conducive to my Enquiry.

Sixthly, to enquire the closeness or rarity of the texture of these bodies, by examining their gravity, and their refraction, &c.

Seventhly, to enquire particularly what operations the fire has upon feveral kinds of Salts, what changes it caufes in their Figures, Textures, or Energies.

Eighthly, to examine their manner of diffolution, or acting upon those bodies diffoluble in them; The texture of those bodies before and after the process. And this for the History.

Next for the Solution, To have examin'd by what, and how many means, fuch and fuch Figures, actions and effects could be produc'd poffibly.

And laftly, from all circumftances well weigh'd, I fhould have endeavoured to have fhewn which of them was most likely, and (if the informations by these Enquiries would have born it) to have demonstrated which of them it must be, and was.

But to proceed, As Ibelieve it next to the Globular the moft fimple; fo do I, in the fecond place, judge it not lefs pleafant; for that which makes an Enquiry pleafant, are, first a noble *Inventum* that promifes to crown the fuccefsfull endeavour; and fuch must certainly the knowledge of the efficient and concurrent causes of all these curious Geometrical Figures be, which has made the Philosophers hitherto to conclude nature in these things to play the Geometrician, according to that faying of *Plato*, 'o Oils yious prime Or next, a great variety of matter in the Enquiry; and here we meet with nothing lefs than the *Mathematicks* of nature, having every day a new Figure to contemplate, or a variation of the fame.

Which do afford us a third thing, which will yet more fweeten the Enquiry, and that is, a multitude of information ; we are not fo much to grope in the dark, as in most other Enquiries, where the Inventum is great; for having fuch a multitude of inftances to compare, and fuch eafie ways of generating, or compounding and of destroying the form, as in the Solution and Crystallization of Salts, we cannot but learn plentifull information to proceed by. And this will further appear from the universality of the Principle which Nature has made use of almost in all inanimate bodies. And therefore, as the contemplation of them all conduces to the knowledg of any one; fo from a Scientifical knowledge of any one does follow the fame of all, and every one. And fourthly, for the ulefulnels of this knowledge, when acquir'd, certainly none can doubt, that confiders that it caries us a step forward into the Labirinth of Nature, in the right way towards the end we propose our felves in all Philosophical Enquiries. So that knowing what is the form of Inanimate or Mineral bodies, we shall be the better able to proceed in our next Enquiry after the forms of Vegetative

VIII.

tive bodies; and last of all, of Animate ones, that seeming to be the highest step of natural knowledge that the mind of man is capable of.

Observ. XIV. Of several kindes of frozen Figures.

I Have very often in a Morning, when there has been a great *boar-froft*, with an indifferently magnifying *Microfcope*, obferv'd the fmall *stirie*, or Cryftalline beard, which then ufually covers the face of moft bodies that lie open to the cold air, and found them to be generally *Hexangular prifmatical* bodies, much like the long Cryftals of *salt-peter*, fave onely that the ends of them were differing: for whereas those of *Nitre* are for the moft part *pyramidal*, being terminated either in a point or edge; these of Froft were hollow, and the cavity in fome feem'd pretty deep, and this cavity was the more plainly to be feen, because usually one or other of the fix *parallelogram* fides was wanting, or at least much fhorter then the reft.

But this was onely the Figure of the Bearded hear-frost; and as for the particles of other kinds of hear-frosts, they feem'd for the most part irregular, or of no certain Figure. Nay, the parts of those curious branchings, or vortices, that usually in cold weather tarnish the surface of Glass, appear through the Microscope very rude and unshapen, as do most other kinds of frozen Figures, which to the naked eye feem exceeding neat and curious, such as the Figures of Snow, frozen Urine, Hail, feveral Figures frozen in common Water, $c \sim c$. Some Observations of each of which I shall hereunto annex, because if well consider'd and exami'nd, they may, perhaps, prove very instructive for the finding out of what I have endeavoured in the preceding Observation to thew, to be (next the Globular Figure which is caus'd by congruity, as I hope I have made probable in the fixth Observation) the most fimple and plain operation of Nature, of which, notwithstanding we are yet ignorant.

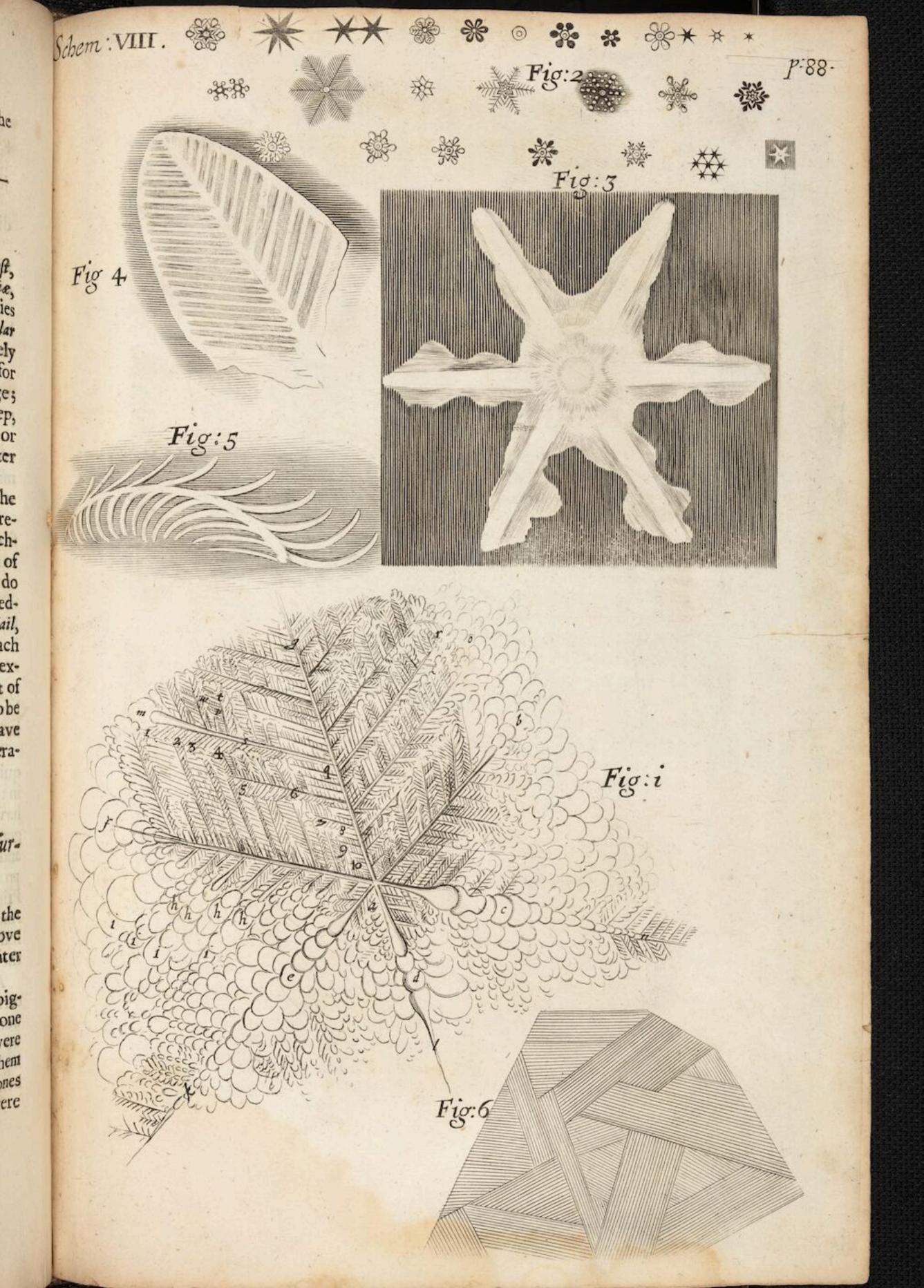
Several Observables in the fix-branched Figures form'd on the furface of Urine by freezing.

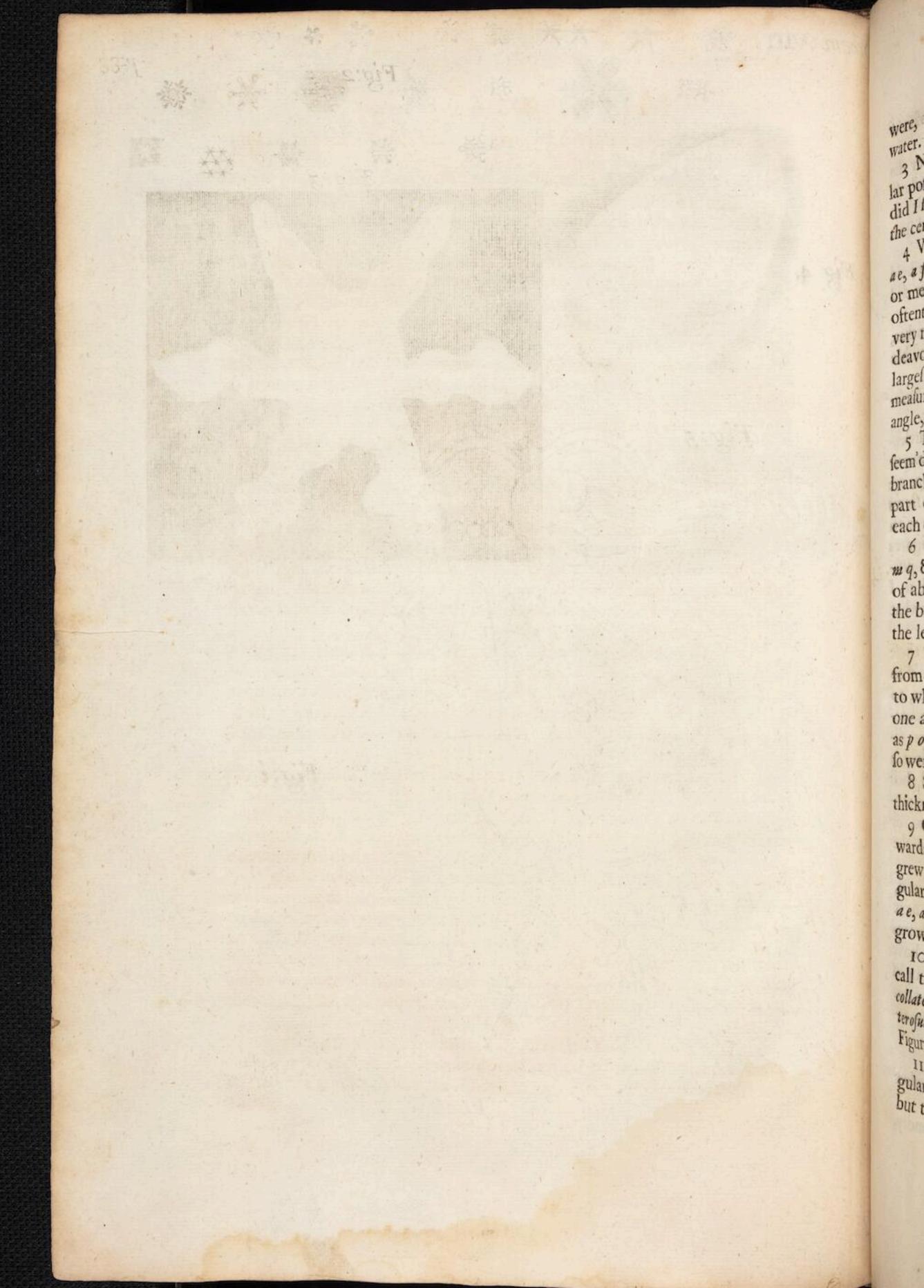
Schem. 8. Fig. 1.

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1 The Figures were all frozen almost even with the furface of the Orine in the Vessel, but the bigger stems were a little prominent above that surface, and the parts of those stems which were nearest the center (a) were biggest above the surface.

2 I have observ'd several kinds of these Figures, some smaller, no bigger then a Two-pence, others so bigg, that I have by measure found one of its stems or branches above four foot long; and of these, some were pretty round, having all their branches pretty neer alike; other of them were more extended towards one side, as usually those very large ones were





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were, which I have observ'd in Ditches which have been full of foul water.

3 None of all these Figures I have yet taken notice of, had any regular position in respect of one another, or of the sides of the Vessel; nor did I find any of them equally to exactness extended every way from the center a.

4 Where ever there was a center, the branchings from it, *ab, ac, ad, ae, af, ag,* were never fewer, or more then fix, which ufually concurr'd, or met one another very neer in the fame point or center, *a*₃ though oftentimes not exactly; and were enclin'd to each other by an angle, of very neer fixty degrees, I fay, very neer, becaufe, though having endeavoured to measure them the most acurately I was able, with the largest Compasses I had, I could not find any sensitive variation from that measure, yet the whole fix-branched Figure sensitive to compose a folid angle, they must necessarily be fomewhat lefs.

5 The middle lines or stems of these branches, *a b*, *a c*, *a d*, *a e*, *a f*, *a g*, feem'd somewhat whiter, and a little higher then any of the *intermediate* branchings of these Figures; and the center *a*, was the most prominent part of the whole Figure, seeming the *apex* of a folid angle or *pyramid*, each of the fix plains being a little enclin'd below the furface of the Urin.

6 The lateral branchings iffuing out of the great ones, fuch as op, mq, &c. were each of them inclin'd to the great ones, by the fame angle of about fixty degrees, as the great ones were one to another, and always the bigger branchings were prominent above the lefs, and the lefs above the leaft, by proportionate gradations.

7 The *lateral* branches fhooting out of the great ones, went all of them from the center, and each of them was parallel to that great branch, next to which it lay; fo that as all the branches on one fide were parallel to one another, fo were they all of them to the *approximate* great branch, as $p \circ$, q r, as they were parallel to each other, and fhot from the center, fo were they parallel alfo to the great branch a b.

8 Some of the stems of the fix branches proceeded straight, and of a thickness that gradually grew sharper towards the end, as ag.

9 Others of the stems of those branches grew bigger and knotty towards the middle, and the branches also as well as stems, from Cylinders grew into Plates, in a most admirable and curious order, so exceeding regular and delicate, as nothing could be more, as is visible in ab, ac, ad, ae, af, but towards the end of some of these stems, they began again to grow smaller and to recover their former branchings, as about k and n. 10 Many of the lateral branches had collateral branches (if I may fo call them) as qm had many such as f t, and most of those again such collateral, as vm, and these again others less, which one may call laterosuccollateral, and these again others, and they others, crc in greater Figures. 11 The branchings of the main Stems joyn'd not together by any regular line, nor did one fide of the one lie over the other fide of the other, but the small collateral and succellateral branches did lie at top of one another

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another according to a certain order or method, which I always observ'd to be this.

12 That fide of a collateral or fubcollateral, &c. branch, lay over the fide of the approximate (as the feathers in the wing of a Bird) whofe branchings proceeded parallel to the last biggest stem from which it fprung, and not to the biggest stem of all, unless that were a second stem backwards.

13 This rule that held in the branchings of the Sexangular Figure held also in the branchings of any other great or fmall stem, though it did not proceed from a center.

14 The exactness and curiofity of the figuration of these branches, was in every particular so transcendent, that I judge it almost impossible for humane art to imitate.

15 Tasting several cleer pieces of this Ice, I could not find any Urinous taste in them, but those few I tasted, seem'd as insipid as water.

16 A figuration fomewhat like this, though indeed in fome particulars much more curious, I have feveral times obferv'd in regulus martis ftellatus, but with this difference, that all the ftems and branchings are bended in a most excellent and regular order, whereas in *Ice* the ftems and branchings are streight, but in all other particulars it agrees with this, and seems indeed nothing but one of these stars, or branched Figures frozen on *Orine*, difforted, or wreathed a little, with a certain proportion: *Lead* also that has *Arfenick* and some other things mixt with it, I have found to have its surface, when suffer'd to cool, figured somewhat like the branchings of *Orine*, but much smaller.

17 But there is a Vegetable which does exceedingly imitate these branches, and that is, Fearn, where the main stem may be observ'd to shoot out branches, and the stems of each of these lateral branches, to send forth collateral, and those subcollateral, and those latero subcollateral, &c. and all those much after the same order with the branchings, divisions, and subdivisions in the branchings of these Figures in frozen Vrine; fo that if the Figures of both be well confider'd, one would ghefs that there were not much greater need of a feminal principle for the production of Fearn, then for the production of the branches of Urine, or the Stella martis, there feeming to be as much form and beauty in the one as in the other. And indeed, this Plant of Fearn, if all particulars be well confider'd, will feem of as fimple, and uncompounded a form as any Vegetable, next to Mould or Mushromes, and would next after the invention of the forms of those, deserve to be enquir'd into; for notwithstanding several have affirm'd it to have feed, and to be propagated thereby; yet, though I have made very diligent enquiry after that particular, I cannot find that there is any part of it that can be imagin'd to be more feminal then another : But this onely here by the by :

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For the freezing Figures in Urine, I found it requifite,

First, that the Superficies be not disturbed with any wind, or other commotion of the air, or the like.

Secondly,

Secondly, that it be not too long exposed, fo as that the whole bulk be frozen, for oftentimes, in fuch cafes, by reason of the swelling the of Ice. or from fome other caufe, the curious branched Figures difappear.

Thirdly, an artificial freezing with snow and salt, apply'd to the outfide of the containing Veffel, fucceeds not well, unless there be a very little quantity in the Vefiel.

Fourthly, If you take any cleer and fmooth Glafs, and wetting all the infide of it with Urine, you expose it to a very tharp freezing, you will find it cover'd with a very regular and curious Figure.

fmail, that I have feareely been able to perceiver her and yet have they been regular, a. I there (as have yet examin d

it) there terms to be but out and the Observables in figur'd Snow.

e that produces both thefe

Exposing a piece of black Cloth, or a black Hatt to the falling Snow, Fig. 2. I have often with great pleafure, observ'd such an infinite variety of curioufly figur'd snow, that it would be as impoffible to draw the Figure and fhape of every one of them, as to imitate exactly the curious and Geometrical Mechanisme of Nature in any one. Some coorse draughts, fuch as the coldness of the weather, and the ill provisions, I had by me for fuch a purpose, would permit me to make, I have here added in the Second Figure of the Eighth Scheme.

In all which I observ'd, that if they were of any regular Figures, they were always branched out with fix principal branches, all of equal length, shape and make, from the center, being each of them inclin'd to either of the next branches on either fide of it, by an angle of fixty degrees.

Now, as all these stems were for the most part in one flake exactly of the fame make, fo were they in differing Figures of very differing ones; fo that in a very little time I have observ'd above an hundred several cizes and shapes of these starry flakes.

The branches also out of each stem of any one of these flakes, were exactly alike in the fame flake; fo that of whatever Figure one of the branches were, the other five were fure to be of the fame, very exactly, that is, if the branchings of the one were fmall Perallelipipeds or Plates, the branchings of the other five were of the fame; and generally, the branchings were very conformable to the rules and method obferv'd before, in the Figures on Urine, that is, the branchings from each fide of the stems were parallel to the next stem on that fide, and if the stems were plated, the branches also were the same; if the stems were very long, the branches also were so, O.c. Observing some of these figur'd flakes with a Microscope, I found them not to appear fo curious and exactly figur'd as one would have imagin'd, but like Artificial Figures, the bigger they were magnify'd, the more irregularites appear'd in them; but this irregularity feem'd afcribable to the thawing and breaking of the flake by the fall, and not at all to the defect of the plastick virtue of Nature, whole curiofity in the formation of most of these kind of regular Figures, such as those of salt. Minerals, &c. appears

Schem. 8.

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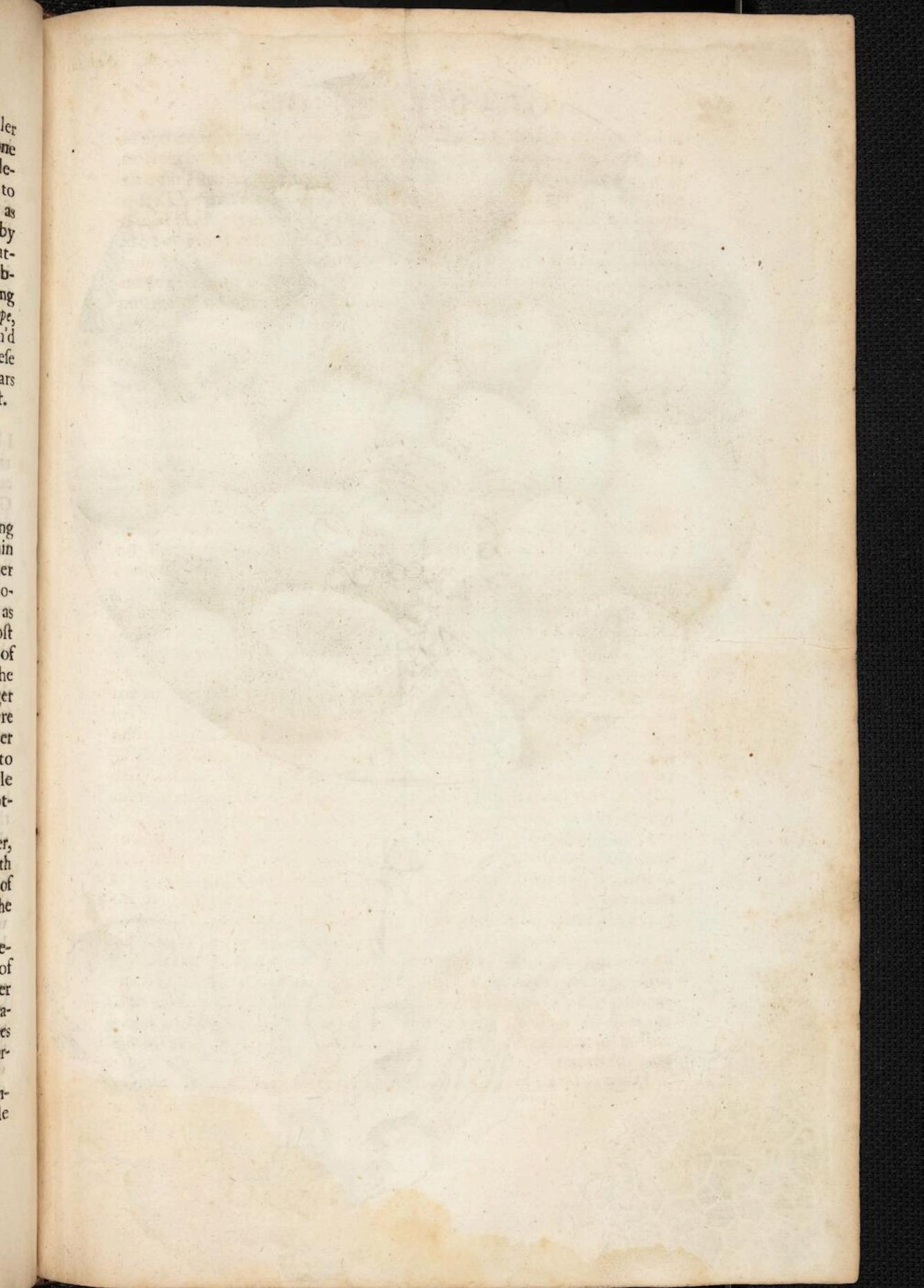
appears by the help of the *Microfcope*, to be very many degrees fmaller then the most acute eye is able to perceive without it. And though one of these fix-branched Stars appear'd here below much of the fhape defcribed in the Third Figure of the Eighth *Scheme*; yet I am very apt to think, that could we have a fight of one of them through a *Microfcope* as they are generated in the Clouds before their Figures are vitiated by external accidents, they would exhibit abundance of curiofity and neatness there also, though never so much magnify'd: For fince I have obferv'd the Figures of *Salts* and *Minerals* to be some of them so exceeding simall, that I have fcarcely been able to perceive them with the *Microfcope*, and yet have they been regular, and fince (as far as I have yet examin'd it) there so be but one and the same cause that produces both these effects, I think it not irrational to suppose that these pretty figur'd Stars of *Snow*, when at first generated might be also very regular and exact.

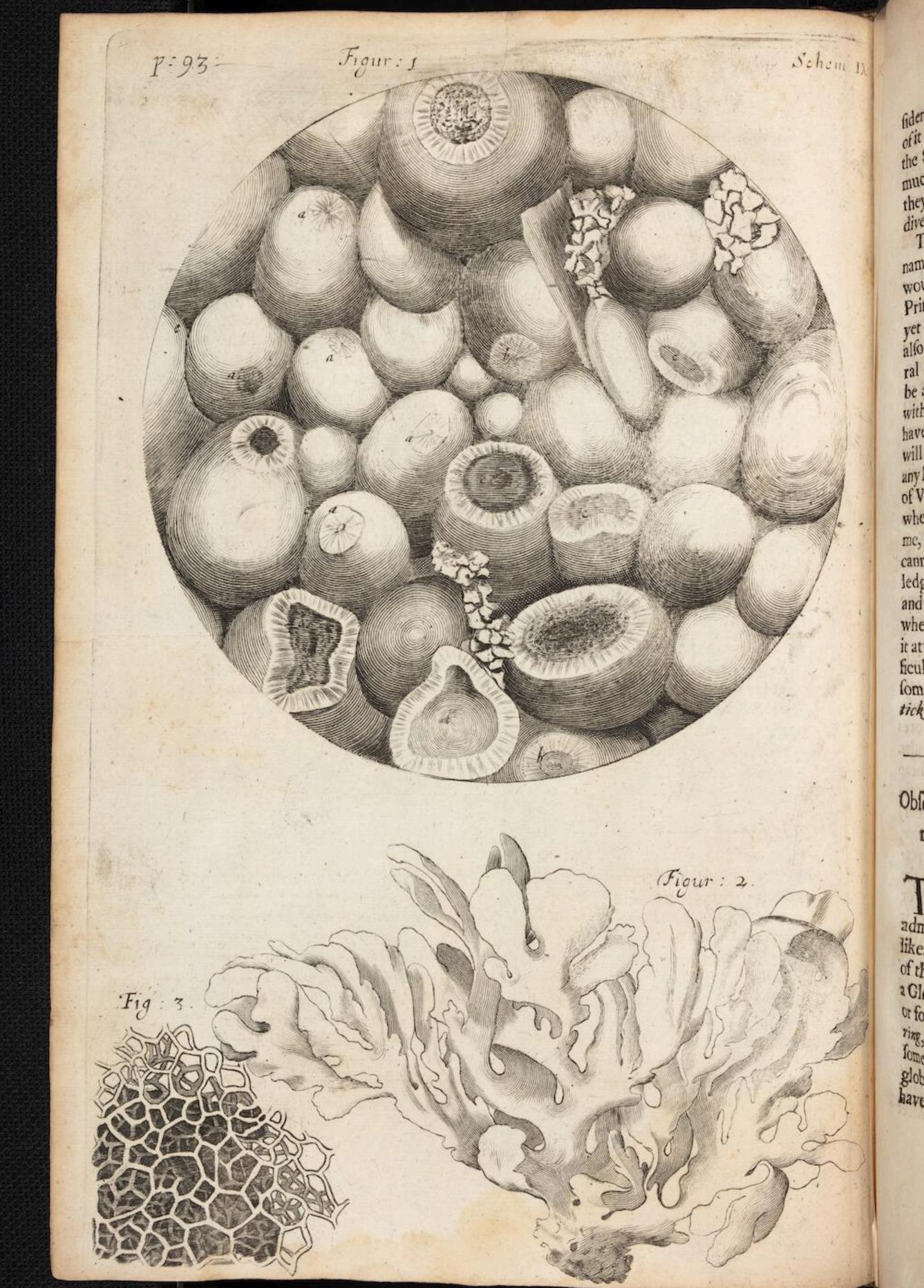
III.

Several kinds of Figures in Water frozen.

Putting fair Water into a large capacious Veffel of Glass, and exposing it to the cold, I observ'd after a little time, several broad, flat, and thin lamine, or plates of Ice, croffing the bulk of the water and one another very irregularly, onely most of them seem'd to turn one of their edges towards that fide of the Glafs which was next it, and feem'd to grow, as 'twere from the infide of the Veffel inwards towards the middle, almost like formany blades of Fern. Having taken feveral of these plates out of water on the blade of a Knife, I observ'd them figur'd much after the manner of Herring bones, or Fern blades, that is, there was one bigger ftem in the middle like the back-bone, and out of it, on either fide, were a multitude of fmall stirie, or icicles, like the smaller bones, or the smaller branches in Fern, each of these branches on the one fide, were parallel to all the reft on the fame fide, and all of them feem'd to make an angle with the ftem, towards the top, of fixty degrees, and towards the bottom or root of this stem, of 120. See the fourth Figure of the 8. Plate. I observ'd likewise several very pretty varieties of Figures in Water, frozen on the top of a broad flat Marble-stone, expos'd to the cold with a little Water on it, some like feathers, some of other shapes, many of them were very much of the shape exprest in the fifth Figure of the 8. Scheme, which is extremely differing from any of the other Figures. I observ'd likewise, that the shootings of Ice on the top of Water, beginning to freez, were in streight prismatical bodies much like those of roch-peter, that they croft each other ufually without any kind of order or rule, that they were always a little higher then the furface of the Water that lay between them; that by degrees those interjacent spaces would be fill'd with Ice allo, which usually would be as high as the furface of the reft.

Inflakes of Ice that had been frozen on the top of Water to any confiderable





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fiderable thickness, I observ'd that both the upper and the under fides of it were curioufly quill'd, furrow'd, or grain'd, as it were, which when the Sun fhone on the Plate, was exceeding eafily to be perceiv'd to be much after the fhape of the lines in the 6. Figure of the 8. scheme, that is, they confifted of feveral streight ends of parallel Plates, which were of divers lengths and angles to one another without any certain order.

The caufe of all which regular Figures (and of hundreds of others, namely of Salts, Minerals, Metals, &c. which I could have here inferted, would it not have been too long) feems to be deducible from the fame Principles, which I have (in the 13. Observation) hinted only, having not yet had time to compleat a Theory of them. But indeed (which I there alfo hinted) I judge it the fecond ftep by which the Pyramid of natural knowledge (which is the knowledge of the form of bodies) is to be ascended: And whosoever will climb it, must be well furnish'd with that which the Noble Verulam calls Scalam Intellectus; he must have fealing Ladders, otherwife the fteps are fo large and high, there will be no getting up them, and confequently little hopes of attaining any higher station, such as to the knowledge of the most simple principle of Vegetation manifested in Mould and Mushromes, which, as I elfewhere endeavoured to shew, seems to be the third step; for it seems to me, that the Intellect of man is like his body, deftitute of wings, and cannot move from a lower to a higher and more fublime fration of knowledg, otherwife then ftep by ftep, nay even there where the way is prepar'd and already made paffible ; as in the Elements of Geometry, or the like, where it is fain to climb a whole series of Propositions by degrees, before it attains the knowledge of one Probleme. But if the afcent be high, difficult and above its reach, it must have recourse to a novum organum, fome new engine and contrivance, fome new kind of Algebra, or Analytick Art before it can furmount it.

Observ. XV. Of Kettering-stone, and of the pores of Inanimate bodies.

Sch.

"His Stone which is brought from Kettering in Northampton-fbire, and schem. 9. digg'd out of a Quarry, as I am inform'd, has a grain altogether Fig. 1. admirable, nor have I ever feen or heard of any other from that has the like. It is made up of an innumerable company of fmall bodies, not all of the same cize or shape, but for the most part, not much differing from a Globular form, nor exceed they one another in Diameter above three or four times; they appear to the eye, like the Cobb or Ovary of a Herring, or fome fmaller fifnes, but for the most part, the particles feem 10mewhat lefs, and not fo uniform; but their variation from a perfect globular ball, seems to be only by the pressure of the contiguous bals which have a little deprest and protruded those toucht fides inward, and forc'd the

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the other fides as much outwards beyond the limits of a Globe; just as it would happen, if a heap of exactly round Balls of fost Clay were heap'd upon one another; or, as I have often seen a heap of small Globules of *Quicksilver*, reduc'd to that form by rubbing it much in a glaz'd Vessel, with some flimy or fluggiss liquor, such as Spittle, when though the top of the upper Globules be very neer spherical, yet those that are press upon by others, exactly imitate the forms of these lately mention'd grains.

Where thefe grains touch each other, they are fo firmly united or fettled together, that they feldom part without breaking a hole in one or th'other of them, fuch as a, a, a, b, c, c, &c. Some of which fractions, as a, a, a, a, where the touch has been but light, break no more then the outward cruft, or firft fhell of the ftone, which is of a white colour, a little dash'd with a brownish Yellow, and is very thin, like the shell of an Egg: and I have seen fome of those grains perfectly refemble fome kind of Eggs, both in colour and shape: But where the union of the contiguous granules has been more firm, there the divulsion has made a greater Chasm, as at b, b, b, in fo much that I have observ'd some of them quite broken in two, as at c, c, c, which has discovered to me a further refemblance they have to Eggs, they having an appearance of a white and yelk, by two differing substances that envelope and encompass each other.

That which we may call the white was pretty whitifh neer the yelk, but more dufkie towards the fhell; fome of them I could plainly perceive to be fhot or radiated like a *Pyrites* or *fire-ftone*; the yelk in fome I faw hollow, in others fill'd with a dufkie brown and porous fubftance like a kind of pith.

The fmall pores, or *interstitia e e e e* betwixt the Globules, I plainly faw, and found by other trials to be every way pervious to air and water, for I could blow through a piece of this stone of a considerable thickness, as easily as I have blown through a Cane, which minded me of the pores which Des Cartes allow his materia subtilis between the athereal globules.

The object, through the Microscope, appears like a Congeries or heap of Pibbles, fuch as I have often feen caft up on the fhore, by the working of the Sea after a great ftorm, or like (in fhape, though not colour) a company of small Globules of Quickfilver, look'd on with a Microfcope, when reduc'd into that form by the way lately mentioned. And perhaps, this last may give some hint at the manner of the formation of the former : For supposing some Lapidescent substance to be generated, or lome way brought (either by fome commixture of bodies in the Sea it self, or protruded in, perhaps, out of some subterraneous caverns) to the bottom of the Sea, and there remaining in the form of a liquor like Quickfilver, heterogeneous to the ambient Saline fluid, it may by the working and tumblings of the Sea to and fro be jumbled and comminuted into fuch Globules as may afterwards be hardned into Flints, the lying of which one upon another, when in the Sea, being not very hard, by reafon of the weight of the incompaffing fluid, may cause the undermost to be a little, though not much, varied from a globular Figure. But this only After by the by.

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After what manner this *Kettering-ftone* fhould be generated I cannot learn, having never been there to view the place, and obferve the circumftances; but it feems to me from the ftructure of it to be generated from fome fubftance once more fluid, and afterwards by degrees growing harder, almost after the fame manner as I fupposed the generation of Flints to be made.

But whatever were the caufe of its curious texture, we may learn this information from it; that even in those things which we account vile, rude, and coorfe, Nature has not been wanting to shew abundance of curiosity and excellent Mechanisme.

We may here find a Stone by help of a *Microfcope*, to be made up of abundance of fmall Balls, which do but just touch each other, and yet there being fo many contacts, they make a firm hard mass, or a Stone much harder then Free-stone.

Next, though we can by a *Microfcope* difcern fo curious a fhape in the particles, yet to the naked eye there fcarce appears any fuch thing's which may afford us a good argument to think, that even in those bodies alfo, whose *texture* we are not able to difcern, though help'd with *Micro-fcopes*, there may be yet *latent* fo curious a *Schematifme*, that it may abundantly fatisfie the curious fearcher, who fhall be fo happy as to find fome way to difcover it.

Next, we here find a Stone, though to the naked eye a very clofe one, yet every way perforated with innumerable pores, which are nothing elfe but the *interftitia*, between those multitudes of minute globular particles, that compose the bulk it felf; and these pores are not only discover'd by the *Microscope*, but by this contrivance.

I took a pretty large piece of this stone, and covering it all over with cement, fave only at two opposite parts, I found my felf able, by blowing in at one end that was left open, to blow my spittle, with which I had wet the other end, into abundance of bubbles, which argued these pores to be open and pervious through the whole stone, which affords us a very pretty inftance of the poroufnefs of fome feemingly clofe bodies, of which kind I shall anon have occasion to subjoyn many more, tending to prove the fame thing. I must not here omit to take notice, that in this body there is not a vegetative faculty that should so contrive this structure for any peculiar use of Vegetation or growth, whereas in the other instances of vegetable porous bodies, there is an anima, or forma informans, that does contrive all the Structures and Mechanismes of the conftituting body, to make them fubfervient and ufefull to the great Work or Function they are to perform. And fo I ghefs the pores in Wood, and other vegetables, in bones, and other Animal fubstances, to be as fo many channels, provided by the Great and Alwife Creator, for the conveyance of appropriated juyces to particular parts. And therefore, that this may tend, or be pervious all towards one part, and may have impediments, as valves or the like, to any other; but in this body we have very little reason to suspect there should be any fuch defign, for it is equally pervious every way, not onely forward,

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ward, but backwards, and fide-ways, and feems indeed much rather to be Homogeneous or fimilar to those pores, which we may with great probability believe to be the channels of pellucid bodies, not directed, or more open any one way, then any other, being equally pervious every way. And, according as these pores are more or greater in respect of the interstitial bodies, the more transparent are the so constituted concretes; and the smaller those pores are, the weaker is the Impulse of light communicated through them, though the more quick be the progrefs.

Upon this Occafion, I hope it will not be altogether unseafonable, if I propound my conjectures and Hypothesis about the medium and conveyance of light.

I suppose then, that the greatest part of the Interstitia of the world, that lies between the bodies of the Sun and Starrs, and the Planets, and the Earth, to be an exceeding fluid body, very apt and ready to be mov'd, and to communicate the motion of any one part to any other part, though never so far distant : Nor do I much concern my self, to determine what the Figure of the particles of this exceedingly fubtile fluid medium must be; nor whether it have any interstitiated pores or vacuities, it being fufficient to folve all the Phanomena to fuppole it an exceedingly fluid, or the most fluid body in the world, and as yet impossible to determine the other difficulties.

That being fo exceeding fluid a body, it eafily gives passage to all other bodies to move to and fro in it.

That it neither receives from any of its parts, or from other bodies; nor communicates to any of its parts, or to any other body, any impulse, or motion in a direct line, that is not of a determinate quickness. And that when the motion is of fuch determinate swiftness, it both receives, and communicates, or propagates an impulse or motion to any imaginable distance in streight lines, with an unimaginable celerity and vigour.

That all kind of folid bodies confift of pretty maffie particles in refpect of the particles of this fluid medium, which in many places do fo touch each other, that none of this fluid medium interpofes much after the fame mannner (to use a gross similitude) as a heap of great stones compais one great congeries or mass in the midst of the water.

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That all fluid bodies which we may call tangible, are nothing but some more subtile parts of those particles, that serve to constiture all tangible bodies.

That the water, and fuch other fluid bodies, are nothing but a congeries of particles agitated or made fluid by it in the fame manner as the particles of salt are agitated or made fluid by a parcel of water, in which they are diffolv'd, and fubfiding to the bottom of it, conftitute a fluid body, much more massie and dense, and less fluid then the pure water it felf.

That the air on the other fide is a certain company of particles of quite another kind, that is, fuch as are very much fmaller, and more eafiely moveable by the motion of this fluid medium; much like those very fubtile parts of Cochenel, and other very deep tinging bodies, where by a very fmall

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fmall parcel of matter is able to tinge and diffuse it felf over a very great quantity of the fluid diffolvent; or fomewhat after that manner, as fmoak, and fuch like minute bodies, or steams, are observed to tinge a very great quantity of air; onely this last similitude is deficient in one propriety, and that is a perpetuity or continuance in that state of commixture with the air, but the former does more neerly approach to the nature and manner of the air's being diffolv'd by this fluid or *Æther*. And this Similitude will further hold in these proprieties; that as those tinctures may be increased by certain bodies, so may they be precipitated by others; as I stall afterwards shew it to be very probable, that the like accidents happen even to the Air it felf.

Further, as these folutions and tinctures do alter the nature of these fluid bodies, as to their aptness to propagate a motion or impulse through them, even so does the particles of the Air, Water, and other fluid bodies, and of Glass, Crystal, &c. which are commixt with this bulk of the Æther, alter the motion of the propagated pulse of light; that is, where these more bulkie particles are more plentifull, and consequently a leffer quantity of the Æther between them to be mov'd, there the motion must necefiarily be the fwister, though not so robust, which will produce those effects, which I have (I hope) with some probability, alcribed to it in the digression about Colours, at the end of the Observations on Muscovy-glass.

Now, that other Stones, and those which have the closeft and hardest textures, and seem (as far as we are able to discover with our eyes, though help'd with the best *Microscopes*) freest from pores, are yet notwithstanding replenish'd with them; an Instance or two will, I suppose, make more probable.

A very folid and unflaw'd piece of eleer white *Marble*, if it be well polifh'd and glaz'd, has fo curioufly fmooth a furface, that the beft and most polish'd furface of any wrought-glass, feems not to the naked eye, nor through a *Microscope*, to be more fmooth, and less porous. And yet, that this hard close body is replenish'd with abundance of pores, I think these following Experiments will sufficiently prove.

The first is, That if you take such a piece, and for a pretty while boyl it in Turpentine and Oyl of Turpentine, you shall find that the stone will be all imbu'd with it; and whereas before it look'd more white, but more opacous, now it will look more greasse, but be much more transparent, and if you let it lie but a little while, and then break off a part of it, you shall find the unctuous body to have penetrated it to such a determinate depth every way within the surface. This may be yet easier try'd with a piece of the same *Marble*, a little warm'd in the fire, and then a little Pitch or Tarr melted on the top of it; for these black bodies, by their infinuating themselves into the invisible pores of the stone, ting it with suffertion, that it abounds with small imperceptible pores. Now, that other bodies will also fink into the pores of *Marble*, besides unstrueus, I have try'd, and found, that a very Blue tincture made in piece of the suffertion of the store of the suffertion of t

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spirit of Urine would very readily and eafily fink into it, as would also feveral tinctures drawn with spirit of Wine.

Nor is *Marble* the only feemingly clofe ftone, which by other kinds of Experiments may be found porous; for I have by this kind of Experiment on divers other ftones found much the fame effect, and in fome, indeed much more notable. Other ftones I have found fo porous, that with the *Microfcope* I could perceive feveral fmall winding holes, much like Worm-holes, as I have noted in fome kind of *Purbeck-ftone*, by looking on the furface of a piece newly flaw'd off; for if otherwife, the furface has been long expos'd to the Air, or has been fcraped with any tool, those fmall caverns are fill'd with duft, and difappear.

And to confirm this *Conjecture*, yet further, I fhall here infert an excellent account, given into the *Royal Society* by that Eminently Learned Phyfician, Doctor *Goddard*, of an Experiment, not lefs inftructive³ then curious and accurate, made by himfelf on a very hard and feemingly clofe ftone call'd *Oculus Mundi*, as I find it preferv'd in the Records of that Honourable Society.

A fmall ftone of the kind, call'd by fome Authours, Oculus Mundi, being dry and cloudy, weigh'd $5\frac{309}{256}$ Grains.

The fame put under water for a night, and fomewhat more, became transparent, and the superficies being wiped dry, weighed $6\frac{3}{356}$ Grains.

The difference between these two weights, $o \frac{50}{250}$ of a Grain.

The fame Stone kept out of water one Day and becoming cloudy again weighed, $5\frac{225}{256}$ Graines.

Which was more then the first weight, $o_{\frac{16}{256}}$ of a Grain. The fame being kept two Days longer weighed, $5_{\frac{202}{256}}^{\frac{202}{256}}$ Graines. Which was less then at first, $o_{\frac{7}{256}}$ of a Grain.

Being kept dry fomething longer it did not grow fenfibly lighter.

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Being put under water for a night and becoming again tranfparent and wiped dry, the weight was, $6\frac{3}{256}$ Grains, the fame with the first after putting in water, and more then the last weight after keeping of it dry, $0\frac{57}{256}$ of a Grain.

Another Stone of the same kind being variegated with milky white and gray like some forts of Agates, while it lay under water, was alwaies invironed with little Bubbles, such as appear in water

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water a little before boyling, next the fides of the Veffel.

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There were also fome the like Bubbles on the Surface of the water just over it, as if either some exhalations came out of it, or that it did excite some fermentation in the parts of the water contiguous to it.

There was little fenfible difference in the transparency of this Stone, before the putting under water, and after : To be fure the milky-white parts continued as before, but more difference in weight then in the former. For whereas before the putting into the water the weight was $18\frac{97}{128}$ Graines. After it had lyen in about four and twenty hours the weight was $20\frac{37}{128}$ Graines, fo the difference was, $1\frac{3^8}{128}$ Graines.

The fame Stone was infufed in the water fealding hot, and fo continued for a while after it was cold, but got no more weight then upon infufing in the cold, neither was there any fenfible Difference in the weight both times.

In which Experiment, there are three Observables, that seem very manifeftly to prove the poroulnels of these feemingly close bodies: the first is their acquiring a transparency, and losing their whiteness after steeping in water, which will feem the more strongly to argue it, if what I have already faid about the making transparent, or clarifying of fome bodies, as the white powder of beaten Glafs, and the froth of fome glutinous transparent liquor be well confider'd; for thereby it will feem rational to think that this transparency arises from the infinuation of the water (which has much the fame refraction with fuch ftony particles, as may be discoverd by Sand view'd with a Microscope) into those pores which were formerly repleat with air (that has a very differing refraction, and confequently is very reflective) which feems to be confirm'd by the fecond Observable, namely, the increase of weight after steeping, and decrease upon drying. And thirdly, seem'd yet more fensibly confirm'd by the mul-Darcoal or titude of bubbles in the laft Experiment. We find also most Acid Salts very readily to disolve and separate the parts of this body one from another ; which is yet a further Argument to confirm the poroushess of bodies, and will serve as such, to shew that even Glass also has an abundance of pores in it, fince there are several liquors, that with long staying in a Glass, will so corrode and cat into it, as at last, to make it pervious to the liquor it contain'd, of which I have , radiant one. Of thele there are a multileen very many Infrances. Since therefore we find by other proofs, that many of those bodies which P 2

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which we think the moft folid ones, and appear fo to our fight, have notwithftanding abundance of those groffer kind of pores, which will admit feveral kinds of liquors into them, why should we not believe that Glass, and all other transparent bodies abound with them, fince we have many other arguments, befides the propagation of light, which seem to argue for it?

And whereas it may be objected, that the propagation of light is no argument that there are those atomical pores in glass, fince there are Hypotheses plausible enough to solve those Phanomena, by supposing the pulse onely to be communicated through the transparent body.

To this I answer, that that Hypothesis which the industrious Moreanus has publish'd about the flower motion of the end of a Ray in a denser medium, then in a more rare and thin, seems altogether unsufficient to solve abundance of Phenomena, of which this is not the least confiderable, that it is impossible from that supposition, that any colours should be generated from the refraction of the Rays; for fince by that Hypothesis the undulating pulse is always carried perpendicular, or at right angles with the Ray or Line of direction, it follows, that the stroke of the pulse of light, after it has been once or twice refracted (through a Prisme, for example) must affect the eye with the fame kind of stroke as if it had not been refracted at all. Nor will it be enough for a Defendant of that Hypothesis, to fay, that perhaps it is because the refractions have made the Rays more weak, for if so, then two refractions in the two parallel fides of a Quadrangular Prisme would produce colours, but we have no such Phenomena produc'd.

There are feveral Arguments that I could bring to evince that there are in all transparent bodies such atomical pores. And that there is such a fluid body as I am arguing for, which is the medium, or Instrument, by which the pulse of Light is convey'd from the *lucid body* to the enlightn'd. But that it being a digression from the Observations I was recording, about the Pores of *Kettering Stone*, it would be too much such if I should protract it too long; and therefore I shall proceed to the next Observation.

Observ. XVI. Of Charcoal, or burnt Vegetables.

Charcoal, or a Vegetable burnt black, affords an object no lefs pleafant than inftructive; for if you take a fmall round Charcoal, and break it fhort with your fingers, you may perceive it to break with a very fmooth and fleek furface, almost like the furface of black fealing Wax; this furface, if it be look'd on with an ordinary *Microscope*, does manifest abundance of those pores which are also visible to the eye in many kinds of *Wood*, rang d round the pith, both a in kind of circular order, and a radiant one. Of these there are a multitude in the fubstance of the Coal, every where almost perforating and drilling it from end to end; by means

means of which, be the Coal never fo long, you may eafily blow through it ; and this you may prefently find, by wetting one end of it with Spittle, and blowing at the other.

But this is not all, for befides those many great and conspicuous irregular spots or pores, if a better Microscope be made use of, there will appear an infinite company of exceedingly fmall, and very regular pores, fo thick and fo orderly fet, and fo clofe to one another, that they leave very little room or space between them to be fill'd with a folid body, for the apparent interstitia, or separating fides of these pores seem so thin in fome places, that the texture of a Honey-comb cannot be more porous. Though this be not every where fo, the intercurrent partitions in fome places being very much thicker in proportion to the holes.

Most of these small pores seem'd to be pretty round, and were rang'd in rows that radiated from the pith to the bark; they all of them feem'd to be continued open pores, running the whole length of the Stick ; and that they were all perforated, I try'd by breaking off a very thin fliver of the Coal crofs-ways, and then with my Microfcope, diligently furveying them against the light, for by that means I was able to see quite through them.

These pores were so exceeding small and thick, that in a line of them, is part of an Inch long, I found by numbring them no lefs then 150. fmall pores 3 and therefore in a line of them an Inch long, must be no lefs then 2700. pores, and in a circular area of an Inch diameter, must be about 5725350. of the like pores; fo that a Stick of an Inch Diameter, may containe no less then seven hundred and twenty five thonsand, befides 5 Millions of pores, which would, I doubt not, feem even incredible, were not every one left to believe his own eyes. Nay, having fince examin'd Cocus, black and green Ebony, Lignum Vita, &c. I found, that all these Woods have their pores, abundantly smaller then those of soft light Wood; in so much, that those of Guajacum seem'd not above an eighth part of the bigness of the pores of Beech, but then the Interstitia were thicker; fo prodigioufly curious are the contrivances, pipes, or fluces by which the succus nutritius, or Juyce of a Vegetable is convey'd from place to place.

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This Observation seems to afford us the true reason of several Phanomena of Coals ; as

First, why they look black; and for this we need go no further then the scheme, for certainly, a body that has fo many pores in it as this is difcover'd to have, from each of which no light is reflected, must necessarily look black, especially, when the pores are somewhat bigger in proportion to the intervals then they are cut in the scheme, black being nothing else but a privation of Light, or a want of reflection; and wherefover this reflecting quality is deficient, there does that part look black, whether it be from a porousness of the body, as in this Instance, or in a deadning and dulling quality, fuch as I have observ'd in the scoria of Lead, Tin, Silver, Copper, C.

Next, we may also as plainly see the reason of its shining quality, and that

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that is from the even breaking off of the flick, the folid *interfiitia* having a regular termination or furface, and having a pretty flrong reflecting quality, the many fmall reflections become united to the naked eye, and make a very pretty flining furface.

Thirdly, the reason of its hardness and brittleness feems evident, for fince all the watery or liquid substance that moistn'd and toughn'd those Interstatic of the more folid parts, are evaporated and remov'd, that which is left hehind becomes of the nature almost of a stone, which will not at all, or very little, bend without a divulsion or folution of its continuity.

It is not my defign at prefent, to examine the use and Mechanisme of these parts of Wood, that being more proper to another Enquiry ; but rather to hint, that from this Experiment we may learn,

First, what is the cause of the blackness of many burnt bodies, which we may find to be nothing else but this; that the heat of the fire agitating and rarifying the waterish, transparent, and volatile water that is contain'd in them, by the continuation of that action, does so totally expel and drive away all that which before fill d the pores, and was dispers'd also through the folid mass of it, and thereby caus'd an universal kind of transparency, that it not onely leaves all the pores empty, but all the *Intersfittia* also so dry and *opacous*, and perhaps also yet further perforated, that that light onely is reflected back which falls upon the very outward edges of the pores, all they that enter into the pores of the body, never returning, but being loss in it.

Now, that the Charring or coaling of a body is nothing elfe, may be eafily believ'd by one that shall confider the means of its production, which may be done after this, or any fuch manner. The body to be charr'd or coal'd, may be put into a Crucible, Pot, or any other Vefiel that will endure to be made red-hot in the Fire without breaking, and then cover'd over with Sand, fo as no part of it be fuffer'd to be open to the Air, then fet into a good Fire, and there kept till the Sand has continu'd red hot for a quarter, half, an hour or two, or more, according to the nature and bigness of the body to be coal'd or charr'd, then taking it out of the Fire, and letting it stand till it be quite cold, the body may be taken out of the Sand well charr'd and cleans'd of its waterish parts; but in the taking of it out, care must be had that the Sand be very neer cold, for elfe, when it comes into the free air, it will take fire, and readily burn away. This may be done also in any close Veffel of Glafs, as a Retort, or the like, and the feveral fluid fubftances that come over may be received in a fit Recipient, which will yet further countenance this Hypothefis : And their manner of charring Wood in great quantity comes much to the fame thing, namely, an application of a great heat to the body, and preferving it from the free access of the devouring air; this may be eafily learn'd from the Hiltory of Charring of Coal, most excellently describ'd and publish'd by that most accomplish'd Gentleman, Mr. John Evelin, in the 100, 101, 103, pages of his Sylva, to which I shall therefore refer the curious Reader that defires a full information of it. Next

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Next, we may learn what part of the Wood it is that is the combuftible matter; for fince we fhall find that none, or very little of those fluid fubftances that are driven over into the Receiver are combustible, and that most of that which is left behind is fo, it follows, that the folid interstitia of the Wood are the combustible matter. Further, the reason why uncharr'd Wood burns with a greater flame then that which is charr'd, is as evident, because those waterish or volatil parts issuing out of the fired Wood, every way, not onely flatter and open the body, the better for the fire to enter, but issuing out in vapours or wind, they become like fo many little *aolipiles*, or Bellows, whereby they blow and agitate the fir'd part, and conduce to the more speedy and violent confumption or diffolution of the body.

Thirdly, from the Experiment of charring of Coals (whereby we fee that notwithstanding the great heat, and the duration of it, the folid parts of the Wood remain, whilest they are preferv'd from the free access of the air undiffipated) we may learn, that which has not, that I know of, been publish'd or hinted, nay, not so much as thought of, by any; and that in short is this.

First, that the Air in which we live, move, and breath, and which encompasses very many, and cheristes most bodies it encompasses, that this Air is the menstruum, or universal dissolvent of all sulphureous bodies.

Secondly, that this action it performs not, till the body be first fufficiently heated, as we find requisite also to the diffolution of many other bodies by feveral other menstruums.

Thirdly, that this action of diffolution, produces or generates a very great heat, and that which we call Fire; and this is common alfo to many diffolutions of other bodies, made by menftrunms, of which I could give multitudes of Inftances.

Fourthly, that this action is perform d with fo great a violence, and does fo minutely act, and rapidly agitate the smallest parts of the combustible matter, that it produces in the diaphanous medium of the Air, the action or pulse of light, which what it is, I have else-where already shewn.

Fifthly, that the diffolution of fulphureous bodies is made by a fubftance inherent, and mixt with the Air, that is like, if not the very fame, with that which is fixt in Salt-peter, which by multitudes of Experiments that may be made with Saltpeter, will, I think, most evidently be demonstrated. Sixthly, that in this diffolution of bodies by the Air, a certain part is united and mixt, or diffolv'd and turn'd into the Air, and made to fly up and down with it in the fame manner as a metalline or other body diffolv'd into any menstruums, does follow the motions and progresses of that menstruum till it be precipitated. Seventhly, That as there is one part that is diffoluble by the Air, fo are there other parts with which the parts of the Air mixing and uniting, do make a Coagulum, or precipitation, as one may call it, which caufes it to be separated from the Air, but this precipitate is so light, and in fo small and rarify'd or porous clusters, that it is very volatil, and is easily carry'd up by the motion of the Air, though afterwards, when the heat and agitation

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agitation that kept it rarify'd ceafes, it eafily condenfes, and commixt with other indiffoluble parts, it sticks and adheres to the next bodies it meets withall; and this is a certain *salt* that may be extracted out of *soot*.

Eighthly, that many indiffoluble parts being very apt and prompt to be rarify'd, and fo, whileft they continue in that heat and agitation, are lighter then the Ambient Air, are thereby thruft and carry'd upwards with great violence, and by that means carry along with them, not onely that *saline concrete* I mention'd before, but many terreftrial, or indiffoluble and irrarefiable parts, nay, many parts alfo which are diffoluble, but are not fuffer'd to ftay long enough in a fufficient heat to make them prompt and apt for that action. And therefore we find in *soot*, not onely a part, that being continued longer in a competent heat, will be diffolv'd by the Air, or take fire and burn; but a part alfo which is fixt, terreftrial, and irrarefiable.

Ninthly, that as there are these several parts that will rarifie and fly, or be driven up by the heat, fo are there many others, that as they are indiffoluble by the aerial menstruum, fo are they of fuch fluggish and gross parts, that they are not eafily rarify'd by heat, and therefore cannot be rais'd by it; the volatility or fixtness of a body seeming to confist only in this, that the one is of a texture, or has component parts that will be eafily rarify'd into the form of Air, and the other, that it has fuch as will not, without much ado, be brought to fuch a conftitution; and this is that part which remains behind in a white body call'd Afhes, which contains a fubstance, or salt, which Chymists call Alkali: what the particular natures of each of these bodies are, I shall not here examine, intending it in another place, but shall rather add that this Hypothesis does fo exactly agree with all Phanomena of Fire, and fo genuinely explicate each particular circumstance that I have hitherto observ'd, that it is more then probable, that this cause which I have affign'd is the true adequate, real, and onely cause of those Phanomena; And therefore I shall proceed a little further, to fhew the nature and use of the Air.

Tenthly, therefore the diffolving parts of the Air are but few, that is, it feems of the nature of those saline menstruums, or spirits, that have very much flegme mixt with the spirits, and therefore a small parcel of it is quickly glutted, and will diffolve no more; and therefore unless fome fresh part of this menstruum be apply'd to the body to be disiolv'd, the action ceafes, and the body leaves to be diffolv'd and to fhine, which is the Indication of it, though plac'd or kept in the greatest heat; whereas Salt-peter is a menstruum, when melted and red-hot, that abounds more with those Dissolvent particles, and therefore as a small quantity of it will diffolve a great fulphureous body, fo will the diffolution be very quick and violent. Therefore in the Eleventh place, it is observable, that, as in other folutions, if a copious and quick fupply of fresh menstruum, though but weak, be poured on, or applied to the diffoluble body, it quickly confumes it : So this menstruum of the Air, if by Bellows, or any other fuch contrivance, it be copioufly apply'd to the fhining body, is found to difiolve

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diffolve it as foon, and as violently as the more ftrong menstrumm of melted Nitre.

Therefore twelfthly, it feems reafonable to think that there is no fuch thing as an Element of Fire that should attract or draw up the flame, or towards which the flame fhould endeavour to afcend out of a defire or appetite of uniting with that as its Homogeneal primitive and generating Element ; but that that fhining transient body which we call Flame, is nothing elfe but a mixture of Air, and volatil fulphureous parts of diffoluble or combuffible bodies, which are acting upon each other whil'ft they afcend, that is, flame feems to be a mixture of Air, and the combuftible volatil parts of any body, which parts the encompaffing Air does diffolve or work upon, which action, as it does intend the heat of the aerial parts of the diffolvent, fo does it thereby further rarifie those parts that are acting, or that are very neer them, whereby they growing much lighter then the heavie parts of that Menstruum that are more remote, are thereby protruded and driven upward; and this may be eafily observ'd alfo in diffolutions made by any other menstrumm, especially such as either create heat or bubbles. Now, this action of the Menftuum, or Air, on the diffoluble parts, is made with fuch violence, or is fuch, that it imparts fuch a motion or pulse to the diaphanous parts of the Air, as I have elfewhere fhewn is requifite to produce light. ay or Earth, which in th

This Hypothesis I have endeavoured to raise from an Infinite of Observations and Experiments, the process of which would be much too long to be here inferted, and will perhaps another time afford matter copious enough for a much larger Discourse, the Air being a Subject which (though all the world has hitherto liv'd and breath'd in, and been unconverfant about) has yet been fo little truly examin'd or explain'd, that a diligent enquirer will be able to find but very little information from what has been (till of late) written of it : But being once well understood, it will, I doubt not, inable a man to render an intelligible, nay probable, if not the true reason of all the Phanomena of Fire, which, as it has been found by Writers and Philosophers of all Ages a matter of no small difficulty, as may be fufficiently underftood by their strange Hypotheses, and unintelligible Solutions of some few Phanomena of it; so will it prove a matter of no fmall concern and use in humane affairs, as I shall elsewhere endeavour to manifest when I come to shew the use of the Air in respiration, and for the prefervation of the life, nay, for the confervation and restauration of the health and natural constitution of mankind as well as all other aereal animals, as also the uses of this principle or propriety of the Air in chymical, mechanical, and other operations. In this place I have onely time to hint an Hypothesis, which, if God permit me life, and opportunity, I may elfewhere profecute, improve and publish. In the mean time, before I finish this Discourse, I must not forget to acquaint the Reader, that having had the liberty granted me of making fome trials on a piece of Lignum fossile shewn to the Royal Society, by the eminently Ingenious and Learned Phyfician, Doctor Ent, who receiv'd it for a Prefent from the famous Ingeniofo Cavalliero de Pozzi, it being one of the fairest and

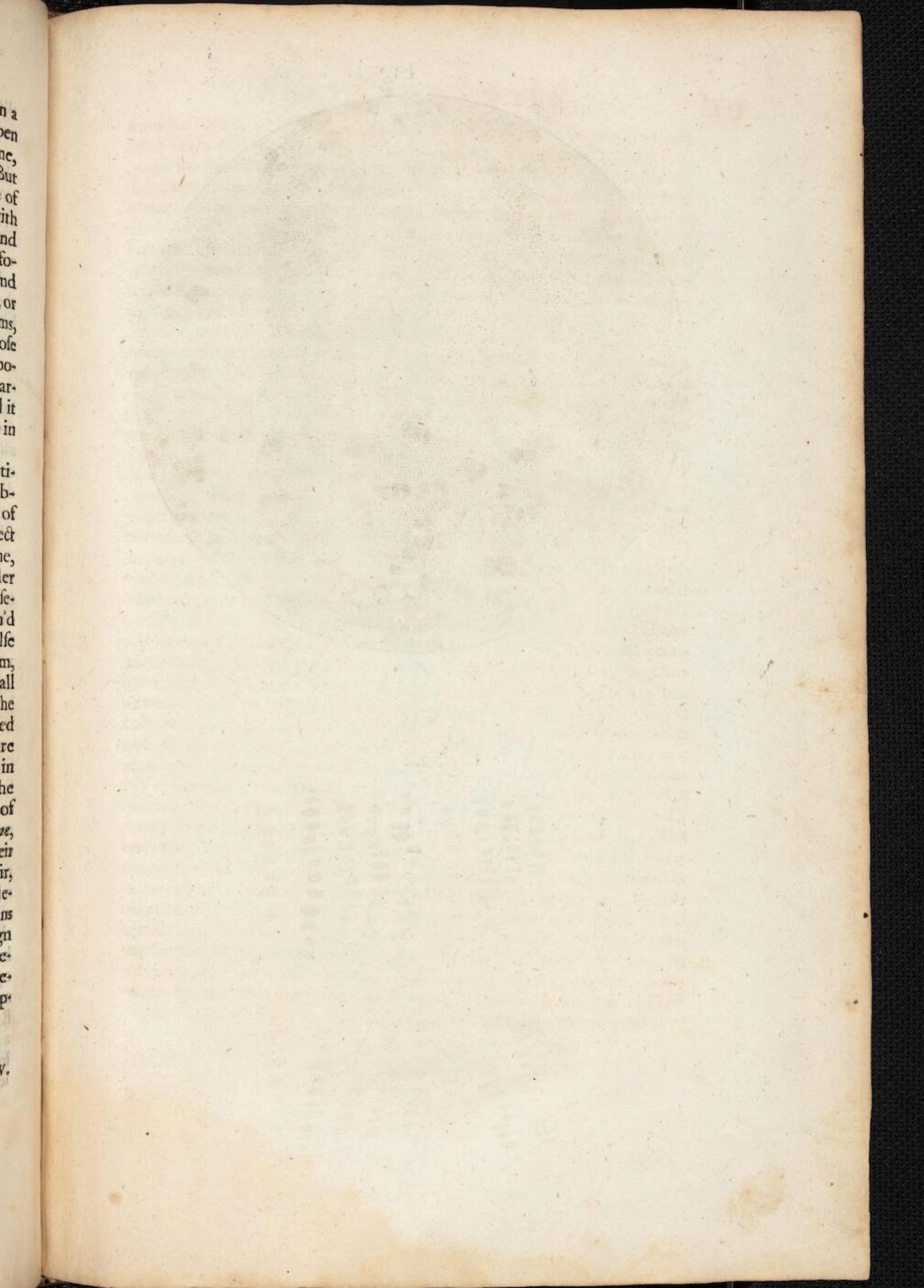
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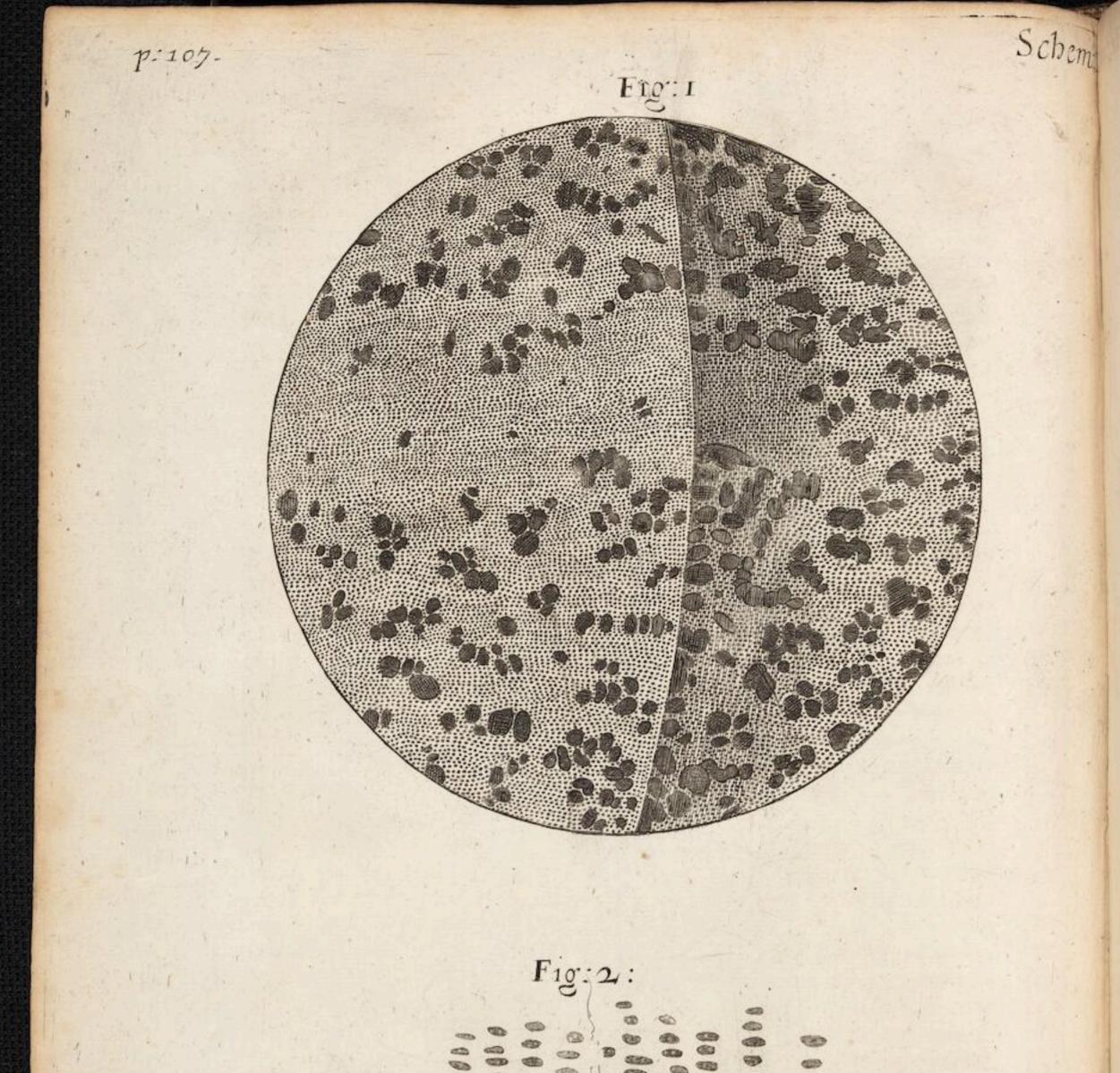
and best pieces of Lignum fossile he had seen; Having (I fay) taken a small piece of this Wood, and examin'd it, I found it to burn in the open Air almost like other Wood, and insteed of a refinous smoak or fume, it yielded a very bituminous one, fmelling much of that kind of fent : But that which I chiefly took notice of, was, that cutting off a small piece of it, about the bignefs of my Thumb, and charring it in a Crucible with Sand, after the manner I above prefcrib'd, I found it infinitely to abound with the smaller fort of pores, so extreme thick, and so regularly perforating the substance of it long-ways, that breaking it off a-cross, I found it to look very like an Honey-comb; but as for any of the fecond, or bigger kind of pores, I could not find that it had any ; fo that it feems, whatever were the caufe of its production, it was not without those fmall kind of pores which we have onely hitherto found in Vegetable bodies : and comparing them with the pores which I have found in the Charcoals that I by this means made of feveral other kinds of Wood, I find it refemble none fo much as those of Firr, to which it is not much unlike in grain alfo, and feveral other proprieties.

And therefore, what ever is by fome, who have written of it, and particularly by Francisco Stelluto, who wrote a Treatise in Italian of that Subject, which was Printed at Rome, 1637. affirm'd that it is a certain kind of Clay or Earth, which in tract of time is turn'd into Wood, I rather fufpect the quite contrary, that it was at first certain great Trees of Fir or Pine, which by some Earthquake, or other cafualty, came to be buried under the Earth, and was there, after a long time's refidence (according to the feveral natures of the encompaffing adjacent parts) either rotted and turn'd into a kind of Clay, or petrify'd and turn'd into a kind of Stone, or elfe had its pores fill'd with certain Mineral juices, which being ftayd in them, and in tract of time coagulated, appear'd, upon cleaving out, like fmall Metaline Wires, or elfe from fome flames or fcorching forms that are the occasion oftentimes, and usually accompanyEarthquakes, might be blafted and turn'd into Coal, or else from certain subterraneous fires which are affirm'd by that Authour to abound much about those parts (namely, in a Province of Italy, call'd Umbria, now the Dutchie of Spoletto, in the Territory of Todi, anciently call'd Tudor; and between the two Villages of Collefecco and Rofaro not far distant from the high-way leading to Rome, where it is found in greater quantity then elfewhere) are by reafon of their being encompassed with Earth, and so kept close from the diffolving Air, charr'd and converted into Coal. It would be too long a work to deferibe the feveral kinds of pores which I met withall, and by this means discovered in several other Vegetable bodies; nor is it my present design to expatiate upon Inftances of the fame kind, but rather to give a Speeimen of as many kinds as I have had opport unity as yet of observing, referving the profecution and enlarging on particulars till a more fit opportunity; and in profecution of this defign, I shall here add: a jobus mean to the Koyal soucey, by the cimment

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ay the male accomplith'd Mir. Evelin, my highly honor

ils Sploa is repletified, and would there one have bee

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Observ. XVII. Of Petrify'd wood, and other Petrify'd bodies.

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F this fort of substance, I observ'd several pieces of very differing kinds, both for their outward shape, colour, grain, texture, hardnefs, &. fome being brown and redifh; others gray, like a Hone; others black, and Flint-like : fome foft, like a Slate or Whetftone, others as hard as a Flint, and as brittle. That which I more particular examin'd, was a piece about the bignefs of a mans hand, which feem'd to have been a part of fome large tree, that by rottennels had been broken off from it before bave a very lovely grain, like that of lor it began to be petrify d.

And indeed, all that I have yet feen, feem to have been rotten Wood before the petrifaction was begun; and not long fince, examining and viewing a huge great Oak, that feem'd with meer age to be rotten as it ftood, I was very much confirm'd in this opinion; for I found, that the grain, colour, and shape of the Wood, was exactly like this petrify'd fub-Stance; and with a Microscope, I found, that all those Microscopical pores, which in fappy or firm and found Wood are fill'd with the natural or innate juices of those Vegetables, in this they were all empty, like those of Vegetables charr'd; but with this difference, that they feem'd much larger then I have feen any in Char-coals; nay, even then those of Coals made of great blocks of Timber, which are commonly call'd Old-coals.

The reason of which difference may probably be, that the charring of Vegetables, being an operation quickly perform'd, and whileft the Wood is fappy, the more folid parts may more eafily fhrink together, and contract the pores or interstitia between them, then in the rotten Wood, where that natural juice feems onely to be wash'd away by adventitious or unnatural moifture; and fo though the natural juice be wafted from between the firm parts, yet those parts are kept afunder by the adventitions moystures, and so by degrees settled in those postures.

And this I likewife found in the petrify'd Wood, that the pores were fomewat bigger then those of Charcoal, each pore being neer upon half as bigg again, but they did not bear that disproportion which is exprest in the tenth scheme, between the small specks or pores in the first Figure (which reprefenteth the pores of Coal or Wood charr'd) and the black fpots of the fecond Figure (which represent the like Microfcopical pores in the petrify'd Wood) for these last were drawn by a Microscope that magnify'd the object above fix times more in Diameter then the Micro-Scope by which those pores of Coal were observ'd. Now, though they were a little bigger, yet did they keep the exact figure and order of the pores of Coals and of rotten Wood, which laft alfo were much of the fame cize. The other Observations on this petrify'd substance, that a while fince, by the appointment of the Royal Society, I made, and prefented to them an account of, were these that follow, which had the honour done them by

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MICROGRAPHIA.

by the most accomplished Mr. Evelin, my highly honour'd friend, to be inferted and published among those excellent Observations wherewith his Sylva is replenished, and would therefore have been here omitted, had not the Figure of them, as they appeared through the Microscope been before that engraven.

This Petrify'd fubstance refembled Wood, in that

First, all the parts of it feem'd not at all *diflocated*, or alter'd from their natural Position, whil's they were Wood, but the whole piece retain'd the exact shape of Wood, having many of the conspicuous pores of wood still remaining pores, and shewing a manifest difference visible enough between the grain of the Wood and that of the bark, especially when any side of it was cut smooth and polite; for then it appear'd to have a very lovely grain, like that of some curious close Wood.

Next (it refembled Wood) in that all the fmaller and (if I may fo call those which are onely visible with a good magnifying Glass) *Microscopi*cal pores of it appear (both when the substance is cut and polish'd transversity and parallel to the pores of it) perfectly like the *Microscopical* pores of several kinds of Wood, especially like and equal to those of several forts of rotten Wood which I have fince observed, retaining both the substance of several kinds of Wood is the several kinds of several kinds of which I have fince observed.

First, in weight, being to common water as 3¹/₄ to 1. whereas there are few of our English Woods, that when very dry are found to be full as heavie as water.

Secondly, in *hardnes*, being very neer as hard as a Flint; and in fome places of it also refembling the grain of a Flint: and, like it, it would very readily cut Glass, and would not without difficulty, especially in fome parts of it, be fcratch'd by a black hard Flint: It would also as readily strike fire against a Steel, or against a Flint, as any common Flint.

Thirdly, in the closeness of it, for though all the Microscopical pores of this petrify'd fubstance were very confpicuous in one position, yet by altering that polition of the polish'd furface to the light, it was also manifeft, that those pores appear'd darker then the rest of the body, onely because they were fill'd up with a more duskie substance, and not becaufe they were hollow. Fourthly, in its incombustibleness, in that it would not burn in the fire; nay, though I kept it a good while red-hot in the flame of a Lamp, made very intense by the blast of a small Pipe, and a large Charcoal, yet it feem'd not at all to have diminish'd its extension; but only I found it to have chang'd its colour, and to appear of a more dark and duskie brown colour; nor could I perceive that those parts which feem'd to have been Wood at first, were any thing wasted, but the parts appear'd as solid and close as before. It was further observable also, that as it did not confume like Wood, fo neither did it crack and flie like a Flint, or fuch like hard Stone, nor was it long before it appear'd red-hot. Fifthly, in its dissolubleness; for putting some drops of distill'd Vinegar upon the Stone, I found it prefently to yield very many Bubbles, just like those which may be observ'd in spirit of Vinegar when it corrodes corals, though

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though perhaps many of those small Bubbles might proceed from some small parcels of Air which were driven out of the pores of this petrify'd substance by the infinuating liquid menstruum.

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Sixthly, in its *rigidness* and *friability*, being not at all flexible but brittle like a Flint, infomuch that I could with one knock of a Hammer break off a piece of it, and with a few more, reduce that into a pretty fine powder.

Seventhly, it feem'd alfo very differing from Wood to the touch, feeling more cold then Wood ufually does, and much like other close ftones and Minerals.

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That this petrify'd Wood having lain in fome place where it was well foak'd with petrifying water (that is, fuch a water as is well impregnated with ftony and earthy particles) did by degrees feparate, either by ftraining and filtration, or perhaps, by precipitation, cohefion or coagulation, abundance of ftony particles from the permeating water, which ftony particles, being by means of the fluid vehicle convey'd, not onely into the Mierofcopical pores, and fo perfectly ftoping them up, but alfo into the pores or interftitia, which may, perhaps, be even in the texture or Schematifme of that part of the Wood, which, through the Microfcope, appears most folid, do thereby fo augment the weight of the Wood, as to make it above three times heavier then water, and perhaps, fix times as heavie as it was when Wood.

Next, they thereby fo lock up and fetter the parts of the Wood, that the fire cannot eafily make them flie away, but the action of the fire upon them is onely able to *Char* those parts, as it were, like a piece of Wood, if it be clos'd very fast up in Clay, and kept a good while red-hot in the fire, will by the heat of the fire be charr'd and not confum'd, which may, perhaps, also be somewhat of the cause, why the *petrify'd* substance appear'd of a dark brown colour after it had been burnt.

By this *intrusion* of the *petrifying* particles, this fubftance also becomes hard and *friable*; for the fmaller pores of the Wood being perfectly wedg'd, and ftuft up with those ftony particles, the fmall parts of the Wood have no places or pores into which they may flide upon bending,

and confequently little or no flexion or yielding at all can be caus'd in fuch a fubstance.

The remaining particles likewife of the Wood among the ftony particles, may keep them from cracking and flying when put into the fire, as they are very apt to do in a Flint.

Nor is Wood the onely fubftance that may by this kind of transmutation be chang'd into ftone; for I my felf have feen and examin'd very many kinds of fubftances, and among very credible Authours, we may meet with Hiftories of fuch Metamorphoses wrought almost on all kind of fubftances, both Vegetable and Animal, which Hiftories, it is not my bufines at prefent, either to relate, or epitomise, but only to fet down fome Observation I lately made on several kind of petrify'd Shels, found about Keinsham, which lies within four or five miles of Bristol, which are commonly call'd Serpentine-stores.

Examining feveral of these very curiously figur'd bodies (which are commonly thought to be Stones form'd by some extraordinary *Plastick virtue latent* in the Earth it self) I took notice of these particulars:

First, that these figured bodies, or stones, were of very differing subftances, as to hardness: some of Clay, some Marle, some soft Stone, almost of the hardness of those soft stones which Masons call Fire-stone, others as hard as Portland stone, others as hard as Marble, and some as hard a a Flint or Crystal.

Next, they were of very differing fubftances as to transparency and colour; some white, some almost black, some brown, some Metalline, or like Marchassites; some transparent like white Marble, others like flaw'd Crystal, some gray, some of divers colours; some radiated like these long petrify'd drops, which are commonly found at the Peak, and in other subterraneous caverns, which have a kind of pith in the middle.

Thirdly, that they were very different as to the manner of their outward figuration; for fome of them feem'd to have been the fubftance that had fill'd the Shell of fome kind of Shel-fift; others, to have been the fubftance that had contain'd or enwrapp'd one of those Shels, on both which, the perfect impression either of the infide or outfide of fuch Shells feem'd to be left, but for the most part, those impressions feem'd to be made by an imperfect or broken Shell, the great end or mouth of the Shell being always wanting, and oftentimes the little end, and fometimes half, and in fome there were impressions, just as if there had been holes broken in the figurating, imprinting or moulding Shell; fome of them feem'd to be made by such a Shell very much bruled or flaw'd, infomuch that one would verily have thought that very figur'd ftone had been broken or brused whilst a gelly, as 'twere, and so hardned, but within in the grain of the ftone, there appear'd not the least fign of any such bruse or breaking, but onely on the very uttermost superficies.

Fourthly, they were very different, as to their outward covering, fome having the perfect Shell, both in figure, colour, and fubstance, sticking on upon its furface, and adhering to it, but might very eafily be feparated from it, and like other common Cockle or Scolop-shels, which some of them most accurately refembled, were very diffoluble in common Vinegar, others of them, especially those Serpentine, or Helical stones were cover'd or retained the fhining or Pearl-colour'd fubstance of the infide of a Shel, which substance, on some parts of them, was exceeding thin, and might very eafily be rubbed off; on other parts it was pretty thick, and retained a white coat, or flaky fubstance on the top, just like the outfides of fuch Shells; fome of them had very large pieces of the Shell very plainly flicking on to them, which were eafily to be broken or flaked off by degrees: they likewife, fome of them retain'd all along the furface of them very pretty kind of *futures*, fuch as are observ'd in the skulls of several kinds of living creatures, which sutures were most curiously shap'd in the manner of leaves, and every one of them in the fame Shell, exactly one like another, which I was able to difcover plainly enough with my naked eye, but more perfectly and diffinctly with my Microfcope; all thele

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these futures, by breaking fome of these ftones, I found to be the termini, or boundings of certain diaphragms, or partitions, which seem'd to divide the cavity of the Shell into a multitude of very proportionate and regular cells or caverns, these Diaphragms, in many of them, I found very perfect and compleat, of a very diffinct substance from that which fill'd the cavities, and exactly of the same kind with that which covered the outfide, being for the most part whitish, or mother-of-pearl colour'd.

As for the cavities between those Diapkragms, I found some of them fill'd with Marle, and others with several kinds of stones, others, for the most part hollow, onely the whole cavity was usually covered over with a kind of tartareous petrify'd substance, which stuck about the sides, and was there shot into very curious regular Figures, just as Tartar, or other dissolv'd Salts are observ'd to stick and crystallize about the sides of the containing Vessels; or like those little *Diamants* which I before obferved to have covered the vaulted cavity of a Flint; others had these cavities all lin'd with a kind of metalline or marchassite-like substance, which with a Microscope I could as plainly see most curiously and regularly figured, as I had done those in a Flint.

From all which, and feveral other particulars which I observ'd, I cannot but think, that all thefe, and most other kinds of stony bodies which are found thus strangely figured, do owe their formation and figuration, not to any kind of Plastick virtue inherent in the earth, but to the Shells of certain Shel-fifhes, which, either by fome Deluge, Inundation, Earthquake, or fome fuch other means, came to be thrown to that place, and there to be fill'd with some kind of Mudd or Clay, or petrifying Water, or fome other fubstance, which in tract of time has been fettled together and hardned in those shelly moulds into those shaped substances we now find them; that the great and thin end of these shells by that Earthquake, or what ever other extraordinay caufe it was that brought them thither, wasbroken off; and that many others were otherwife broken, bruifed and disfigured ; that these Shells which are thus spirallied and feparated with Diaphragmes, were some kind of Nautili or Porcelane shells ; and that others were shells of Cockles, Muscles, Perimincles, Scolops, &c. of various forts; that these Shells in many, from the particular nature of the containing or enclos'd Earth, or fome other caufe, have in tract of time rotted and mouldred away, and onely left their imprefiions, both on the containing and contained substances; and so left them pretty loose one within another, fo that they may be eafily separated by a knock or two of a Hammer. That others of these Shells, according to the nature of the fubstances adjacent to them, have, by a long continuance in that posture, been petrify'd and turn'd into the nature of stone, just as I even now observ'd feveral forts of Wood to be. That oftentimes the Shell may be found with one kind of substance within, and quite another without, having, perhaps, been fill'd in one place, and afterwards tranflated to another, which I have very frequently observ'd in Cockle, Mufele, Periwincle, and other shells, which I have found by the Sea fide. Nay, further, that fome parts of the fame Shell may be fill'd in one place, and iome

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MICROGRAPHIA.

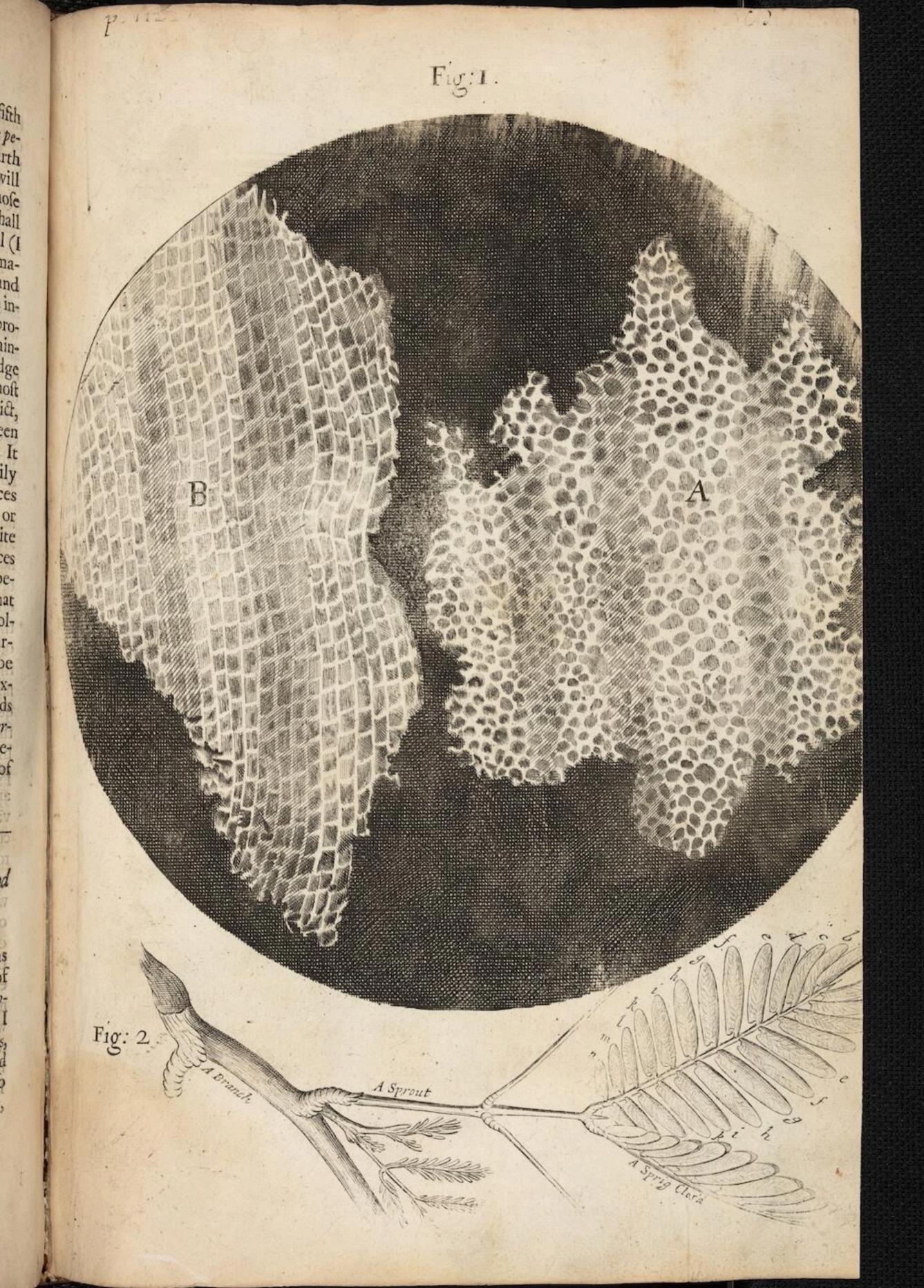
fome other caverns in another, and others in a third, or a fourth, or a fifth place, for fo many differing fubftances have I found in one of these petrify'd Shells, and perhaps all these differing from the encompassing earth or ftone; the means how all which varieties may be caus'd, I think, will not be difficult to conceive, to any one that has taken notice of those Shells, which are commonly found on the Sea fhore : And he that fhall throughly examine feveral kinds of fuch curioufly form'd ftones, will (I am very apt to think) find reason to suppose their generation or formation to be ascribable to some such accidents as I have mention'd, and not to any Plastick virtue : For it feems to me quite contrary to the infinite prudence of Nature, which is observable in all its works and productions, to defign every thing to a determinate end, and for the attaining of that end, makes use of such ways as are (as farr as the knowledge of man has yet been able to reach) altogether confonant, and most agreeable to man's reason, and of no way or means that does contradict, or is contrary to humane Ratiocination; whence it has a long time been a general observation and maxime, that Nature does nothing in vain; It feems, I fay, contrary to that great Wildom of Nature, that these prettily shap'd bodies should have all those curious Figures and contrivances (which many of them are adorn'd and contriv'd with) generated or wrought by a Plastick virtue, for no higher end then onely to exhibite fuch a form; which he that fhall throughly confider all the circumstances of fuch kind of Figur'd bodies, will, I think, have great reason to believe, though, I confess, one cannot presently be able to find out what Nature's defigns are. It were therefore very defirable, that a good collection of fuch kind of figur'd ftones were collected; and as many particulars, circumstances, and informations collected with them as could be obtained, that from fuch a Hiftory of Observations well rang'd, examin'd and digested, the true original or production of all those kinds, of stones might be perfectly and surely known; such as are Thunder-Stones, Lapides Stellares, Lapides Judaici, and multitudes of other, whereof mention is made in Aldrovandus Wormius, and other Writers of Minerals.

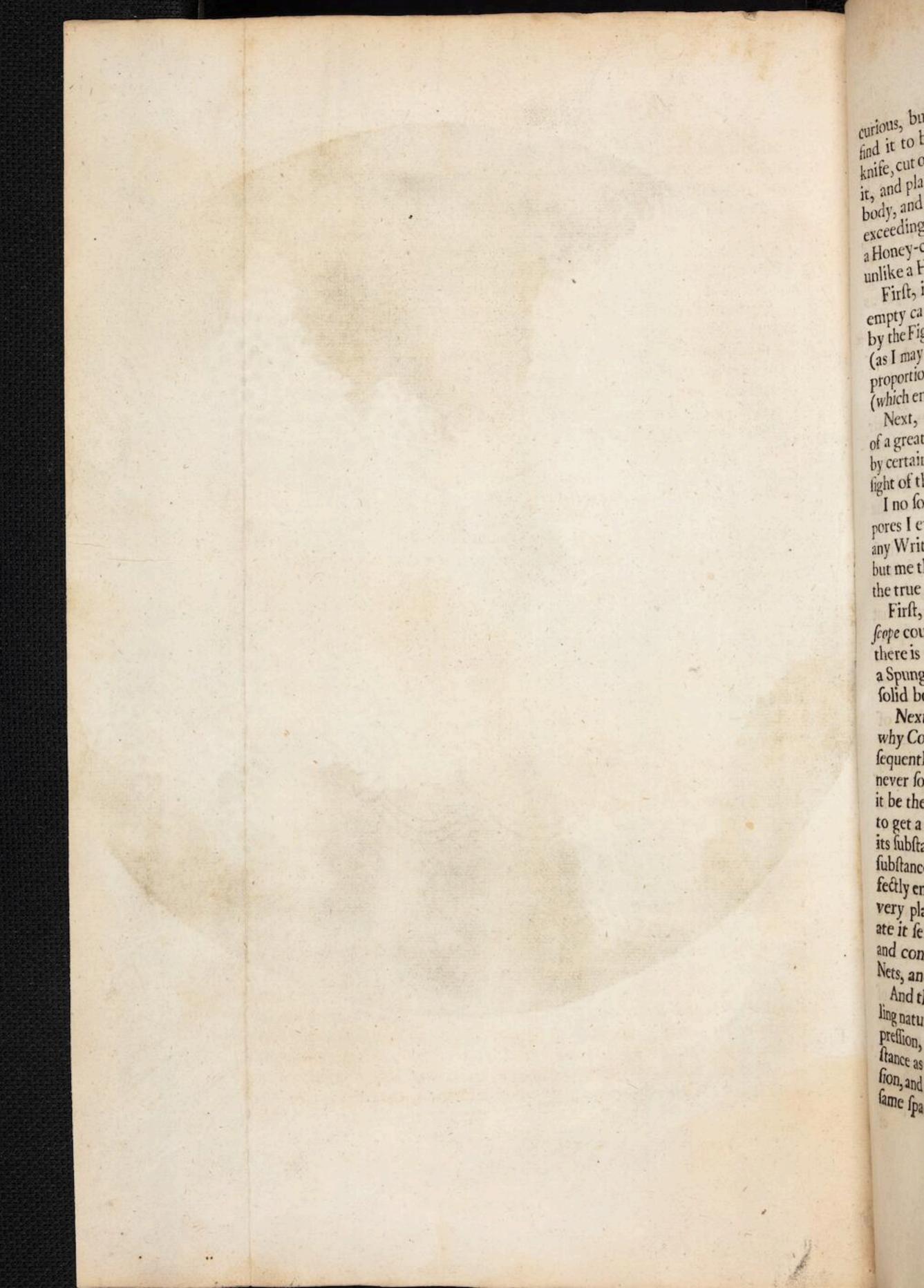
Observ. XVIII. Of the Schematisme or Texture of Cork, and of the Cells and Pores of some other such frothy Bodies.

various forts; that thele shells in many, from the part

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Took a good clear piece of Cork, and with a Pen-knife fharpen'd as keen as a Razor, I cut a piece of it off, and thereby left the furface of it exceeding fmooth, then examining it very diligently with a *Microfcope*, me thought I could perceive it to appear a little porous; but I could not fo plainly diftinguifh them, as to be fure that they were pores, much lefs what Figure they were of : But judging from the lightnefs and yielding quality of the Cork, that certainly the texture could not be fo curious,





curious, but that poffibly, if I could use fome further diligence, I might find it to be difcernable with a *Microfcope*, I with the fame sharp Penknife, cut off from the former smooth surface an exceeding thin piece of it, and placing it on a black object Plate, because it was it felf a white body, and calting the light on it with a deep *plano-convex Glass*, I could exceeding plainly perceive it to be all perforated and porous, much like a Honey-comb, but that the porces of it were not regular; yet it was not unlike a Honey-comb in these particulars.

First, in that it had a very little solid substance, in comparison of the empty cavity that was contain'd between, as does more manifestly appear by the Figure A and B of the X I. scheme, for the Interstitia, or walls (as I may so call them) or partitions of those pores were neer as thin in proportion to their pores, as those thin films of Wax in a Honey-comb (which enclose and constitute the fexangular cells) are to theirs.

Next, in that these pores, or cells, were not very deep, but confisted of a great many little Boxes, separated out of one continued long pore, by certain *Diapkragms*, as is visible by the Figure B, which represents a sight of those pores split the long-ways.

I no fooner difern'd these (which were indeed the first microscopical pores I ever faw, and perhaps, that were ever seen, for I had not met with any Writer or Person, that had made any mention of them before this) but me thought I had with the discovery of them, presently hinted to me the true and intelligible reason of all the *Phænomena* of Cork; As,

First, if I enquir'd why it was so exceeding light a body? my *Microfcope* could prefently inform me that here was the same reason evident that there is found for the lightness of froth, an empty Honey-comb, Wool, a Spunge, a Pumice-stone, or the like; namely, a very small quantity of a folid body, extended into exceeding large dimensions.

Next, it feem'd nothing more difficult to give an intelligible reafon, why Cork is a body fo very unapt to fuck and drink in Water, and confequently preferves it felf, floating on the top of Water, though left on it never fo long : and why it is able to ftop and hold air in a Bottle, though it be there very much condens'd and confequently prefles very ftrongly to get a passage out, without suffering the least bubble to pass through its fubstance. For, as to the first, fince our Microscope informs us that the fubstance of Cork is altogether fill'd with Air, and that that Air is perfectly enclosed in little Boxes or Cells diftinct from one another. It feems very plain, why neither the Water, nor any other Air can eafily infinuate it felf into them, fince there is already within them an intus existens, and confequently, why the pieces of Cork become fo good floats for Nets, and stopples for Viols, or other close Veffels. And thirdly, if we enquire why Cork has fuch a fpringinels and fwelling nature whem compress'd? and how it comes to fuffer fo great a compreffion, or feeming penetration of dimensions, so as to be made a sub-Itance as heavie again and more, bulk for bulk, as it was before compreftion, and yet fuffer'd to return, is found to extend it felf again into the tame space? Our Microscope will easily inform us, that the whole mais confifts R

confifts of an infinite company of fmall Boxes or Bladders of Air, which is a fubftance of a fpringy nature, and that will fuffer a confiderable condenfation (as I have feveral times found by divers trials, by which I have moft evidently condens'd it into lefs then a twentieth part of its ufual dimenfions neer the Earth, and that with no other ftrength then that of my hands without any kind of forcing Engine, fuch as Racks, Leavers, Wheels, Pullies, or the like, but this onely by and by) and befides, it feems very probable that those very films or fides of the pores, have in them a fpringing quality, as almost all other kind of Vegetable fubftances have, fo as to help to reftore themselves to their former position.

And could we fo eafily and certainly difcover the *schematifme* and *Texture* even of these films, and of several other bodies, as we can these of Cork; there seems no probable reason to the contrary, but that we might as readily render the true reason of all their *Phenomena*; as namely, what were the cause of the springines, and toughness of some, both as to their flexibility and restitution. What, of the friability or brittleness of some other means, enable us to discover the true *schematifm* and *Texture* of all kinds of bodies, we must grope, as it were, in the dark, and onely ghess at the true reasons of things by fimilitudes and comparisons.

But, to return to our Observation. I told several lines of these pores, and found that there were ufually about threefcore of thefe fmall Cells placed end-ways in the eighteenth part of an Inch in length, whence I concluded there must be neer eleven hundred of them, or somewhat more then a thousand in the length of an Inch, and therefore in a square Inch above a Million, or 1166400. and in a Cubick Inch, above twelve hundred Millions, or 1259712000. a thing almost incredible, did not our Microscope assure us of it by ocular demonstration; nay, did it not discover to us the pores of a body, which were they diaphragm'd, like those of Cork, would afford us in one Cubick Inch, more then ten times as many little Cells, as is evident in feveral charr'd Vegetables; fo prodigioufly curious are the works of Nature, that even these confpicuous pores of bodies, which feem to be the channels or pipes through which the Succus nutritius, or natural juices of Vegetables are convey'd, and feem to correspond to the veins, arteries and other Vessels in fensible creatures, that these pores I say, which seem to be the Vessels of nutrition to the vastest body in the World, are yet fo exceeding fmall, that the Atoms which Epicurus fancy'd would go neer to prove too bigg to enter them, much more to conftitute a fluid body in them. And how infinitely fmaller then must be the Vessels of a Mite, or the pores of one of those little Vegetables I have discovered to grow on the back-fide of a Rose-leaf, and shall anon more fully defcribe, whole bulk is many millions of times lefs then the bulk of the fmall fhrub it grows on; and even that fhrub, many millions of times lefs in bulk then feveral trees (that have heretofore grown in England, and are this day flourishing in other hotter Climates, as we are very credibly inform'd) if at least the pores of this small Vegetable should keep any fuch proportion to the body of it, as we have found these pores of COBBILIS

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of other Vegetables to do to their bulk. But of these pores I have faid more elsewhere.

To proceed then, Cork feems to be by the transverse constitution of the pores, a kind of *Fungus* or Mushrome, for the pores lie like so many Rays tending from the center, or pith of the tree, outwards; so that if you cut off a piece from a board of Cork transversely, to the flat of it, you will, as it were, split the pores, and they will appear just as they are expressed in the Figure B of the XI. *Scheme*. But if you shave off a very thin piece from this board, parallel to the plain of it, you will cut all the pores transversely, and they will appear almost as they are express'd in the Figure A, fave onely the folid *Interstitia* will not appear fo thick as they are there represented.

So that Cork feems to fuck its nourifhment from the fubjacent bark of the Tree immediately, and to be a kind of excrefcence, or a fubftance distinct from the substances of the entire Tree, something analogus to the Mushrome, or Mols on other Trees, or to the hairs on Animals. And having enquir'd into the Hiftory of Cork, I find it reckoned as an excrescency of the bark of a certain Tree, which is distinct from the two barks that lie within it, which are common also to other trees; That 'tis fome time before the Cork that covers the young and tender fprouts comes to be difcernable; That it cracks, flaws, and cleaves into many great chaps, the bark underneath remaining entire; That it may be feparated and remov'd from the Tree, and yet the two under-barks (fuch as are alfo common to that with other Trees) not at all injur'd, but rather helped and freed from an external injury. Thus Jonftonus in Dendrologia, speaking de Subere, says, Arbor est procera, Lignum est robustum, dempto cortice in aquis non fluitat, Cortice in orbem detracto juvatur, crascescens enim præstringit & strangulat, intra triennium iterum repletur : Caudex ubi adolescit crassus, cortex superior densus carnosus, duos digitos crassus, scaber, rimosus, & qui nist detrahatur dehiscit, alioque subnascente expellitur, interior qui subest novellus ita rubet ut arbor minio picta videatur. Which Hiftories, if well confider'd, and the tree, fubftance, and manner of growing, if well examin'd, would, I am very apt to believe, much confirm this my conjecture about the origination of Cork.

Nor is this kind of Texture peculiar to Cork onely; for upon examination with my *Microfcope*, I have found that the pith of an Elder, or almoft any other Tree, the inner pulp or pith of the Cany hollow ftalks of feveral other Vegetables: as of Fennel, Carrets, Daucus, Bur-docks, Teafels, Fearn, fome kinds of Reeds, Oc. have much fuch a kind of *Schematifine*, as I have lately fhewn that of Cork, fave onely that here the pores are rang'd the long-ways, or the fame ways with the length of the Cane, whereas in Cork they are transverfe. The pith alfo that fills that part of the ftalk of a Feather that is above the Quil, has much fuch a kind of texture, fave onely that which way foever I fet this light fubfrance, the pores feem'd to be cut transverfly; fo that I ghefs this pith which fills the Feather, not to confift of abundance of long pores feparated with Diaphragms, as Cork does, but to be a kind R 2 of

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of folid or hardned froth, or a congeries of very fmall bubbles confolidated in that form, into a pretty stiff as well as tough concrete, and that each Cavern, Bubble, or Cell, is diffinctly separate from any of the rest, without any kind of hole in the encompassing films, so that I could no more blow through a piece of this kinde of fubstance, then I could through a piece of Cork, or the found pith of an Elder.

But though I could not with my Microscope, nor with my breath, nor any other way I have yet try'd, discover a passage out of one of those cavities into another, yet I cannot thence conclude, that therefore there are none fuch, by which the Succus nutritius, or appropriate juices of Vegetables, may pass through them; for, in several of those Vegetables, whil'ft green, I have with my Microscope, plainly enough discover'd these Cells or Poles fill'd with juices, and by degrees fweating them out : as I have also observed in green Wood all those long Microscopical pores which appear in Charcoal perfectly empty of any thing but Air.

Now, though I have with great diligence endeavoured to find whether there be any fuch thing in those Microscopical pores of Wood or Piths, as the Valves in the heart, veins, and other passages of Animals, that open and give paffage to the contain'd fluid juices one way, and fhut themfelves, and impede the paffage of fuch liquors back again, yet have I not hitherto been able to fay any thing politive in it; though, me thinks, it feems very probable, that Nature has in these passages, as well as in those of Animal bodies, very many appropriated Inftruments and contrivances, whereby to bring her defigns and end to pafs, which 'tis not improbable, but that fome diligent Observer, if help'd with better Microscopes, may in time detect.

And that this may be fo, feems with great probability to be argued from the strange Phanomena of sensitive Plants, wherein Nature seems to perform feveral Animal actions with the fame Schematifm or Orginization that is common to all Vegetables, as may appear by fome no lefs instructive then curious Observations that were made by divers Eminent Members of the Royal Society on fome of these kind of Plants, whereof an account was delivered in to them by the most Ingenious and Excellent Phylician, Doctor Clark, which, having that liberty granted me by that most Illustrious Society, I have hereunto adjoyn'd.

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Observations on the Humble and Senfible Plants in M. Chiffin's Garden in Saint James's Park, made August the 9th, 1661. Present, the Lord Brouncker, Sr. Robert Moray, Dr. Wilkins, Mr. Evelin, Dr. Henfbaw, and Dr. Clark.

There are four Plants, two of which are little shrub Plants, with a little fhort ftock, about an Inch above the ground, from whence are spread several sticky branches, round, streight, and fmooth,

fmooth in the distances between the Sprouts, but just under the Sprouts there are two fharp thorny prickles, broad in the letting on, as in the Bramble, one just under the Sprout, the other on the opposite fide of the branch. but of its erlound

The distances betwixt the Sprouts are usually fomething See Schem. 11. more then an Inch, and many upon a Branch, according to its Fig. 2. length, and they grew fo, that if the lower Sprout be on the left fide of the Branch, the next above is on the right, and fo to the end, not sprouting by pairs.

At the end of each Sprout are generally four fprigs, two at the Extremity, and one on each fide, just under it. At the first fprouting of these from the Branch to the Sprig where the leaves grow, they are full of little fhort white hairs, which wear off as the leaves grow, and then they are fmooth as the Branch. It in

Upon each of these sprigs, are, for the most part, eleven pair of leaves, neatly fet into the uppermost part of the little fprig, exactly one against another, as it were in little articulations, fuch as Anatomists call Enarthrofis, where the round head of a Bone is received into another fitted for its motion; and standing very firly to thut themselves and touch, the pairs just above them clofing fomewhat upon them, as in the fhut fprig; fo is the little round Pedunculus of this leaf fitted into a little cavity of the sprig, visible to the eye in a sprig new pluck'd, or in a sprig withered on the Branch, from which the leaves eafily fall by

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low on the fune Iprig, green, and cioing upon ti touching.

The leaf being almost an oblong square, and set into the Pedunculus, at one of the lower corners, receiveth from that not onely a Spine, as I may call it, which, passing through the leaf, divides it fo length-ways that the outer-fide is broader then the inner next the sprig, but little fibres paffing obliquely towards the opposite broader fide, seem to make it here a little muscular, and fitted to move the whole leaf, which, together with the whole fprig, are fet full with little fhort whitifh hairs. and down One

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MICROGRAPHIA.

One of these Plants, whose branch seem'd to be older and more grown then the other, onely the tender Sprouts of it, after the leaves are shut, fall and hang down; of the other, the whole branches fall to the ground, if the Sun shine very warm, upon the first taking off the Glass, which I therefore call the *bumble Plant*.

The other two, which do never fall, nor do any of their branches flagg and hang down, fhut not their leaves, but upon fomewhat a hard ftroke; the ftalks feem to grow up from a root, and appear more *herbaceous*, they are round and fmooth, without any prickle, the Sprouts from them have feveral pairs of fprigs, with much lefs leaves then the other on them, and have on each fprig generally feventeen pair.

Upon touching any of the sprigs with leaves on, all the leaves on that sprig contracting themselves by pairs, joyned their upper superficies close together.

Upon the dropping a drop of Aqua fortis on the fprig betwixt the leaves, f f all the leaves above that prefently, those below by pairs fucceffively after, and by the lower leaves of the other branches, II, kk, &c. and fo every pair fucceffively, with fome little diftance of time betwixt, to the top of each fprig, and fo they continu'd that all the time we were there. But I returning the next day, and feveral days fince, found all the leaves dilated again on two of the fprigs; but from f f, where the Aqua fortis had dropped upwards, dead and withered; but those be-

low on the fame fprig, green, and clofing upon the touch, and are fo at this day, August 14.

With a pair of Sciffers, as fuddenly as it could be done, one of the leaves b b was clipped off in the middle, upon which that pair, and the pair above, closed prefently, after a little interval, d d, then e e, and fo the reft of the pairs, to the bottom of the fprig, and then the motion began in the lower pairs, l l, on the other fprigs, and fo fhut them by pairs upwards, though not with fuch diftinct diftances.

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Under a pretty large branch with its fprigs on, there lying a large Shell betwixt two and three Inches below it, there was rubbed on a ftrong fented oyl, after a little time all the leaves on that fprig were fhut, and fo they continued all the time of our ftay there, but at my returne the next day, I found the pofition of the Shell alter'd, and the leaves expanded as before, and clofing upon the touch.

Upon the application of the Sun-beams by a Burning-glafs, the more *humble Plant* fell, the other fhut their leaves.

We could not fo apply the fmoak of Sulpher, as to have any visible effect from that, at two or three times trial; but on another trial, the smoak touching the leaves, it succeeded.

The humble Plant fell upon taking off the Glafs wherewith it was covered.

Cutting off one of the little Sprouts, two or three drops of liquor were thruft out of the part from whence that was cut, very cleer, and pellucid, of a bright greenifh colour, tafting at firft a little bitterifh, but after leaving a licorifh-like tafte in my mouth. Since, going two or three times when it was cold, I took the Glaffes from the more *humble Plant*, and it did not fall as formerly, but fhut its leaves onely. But coming afterwards, when the Sun fhone very warm, as foon as it was taken off, it fell as before.

Since I pluck'd off another fprig, whole leaves were all shut,

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and had been fo fome time, thinking to obferve the liquor fhould come from that I had broken off, but finding none, though with preffing, to come, I, as dexteroufly as I could, pull'd off one whofe leaves were expanded, and then had upon the flutting of the leaves, a little of the mention'd liquor, from the end of the fprig I had broken from the Plant. And this twice fucceffively, as often almost as I durft rob the Plant.

But my curiofity carrying me yet further, I cut off one of the harder branches of the stronger Plant, and there came of the liquor,

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liquor, both from that I had cut, and that I had cut it from, without preffure.

Which made me think, that the motion of this Plant upon touching, might be from this, that there being a constant intercourse betwixt every part of this Plant and its root, either by a circulation of this liquor, or a constant preffing of the subtiler parts of it to every extremity of the Plant. Upon every preffure, from whatfoever it proceeds, greater then that which keeps it up, the fubtile parts of this liquor are thrust downwards, towards its articulations of the leaves, where, not having room prefently to get into the sprig, the little round pedunculus, from whence the Spine and those oblique Fibres I mention'd rife, being dilated, the Spine and Fibres (being continued from it) must be contracted and shortned, and so draw the leaf upwards to joyn with its fellow in the fame condition with it felf, where, being closed, they are held together by the implications of the little whitish hair, as well as by the still retreating liquor, which distending the Fibres that are continued lower to the branch and root, fhorten them above ; and when the liquor is fo much forced from the Sprout, whose Fibres are yet tender, and not able to support themselves, but by that tenfnefs which the liquor filling their interffices gives them, the Sprout hangs and flags.

But, perhaps, he that had the ability and leifure to give you the exact Anatomy of this pretty Plant, to fhew you its Fibres, and vifible Canales, through which this fine liquor circulateth, or is moved, and had the faculty of better and more copioufly expreffing his Obfervations and conceptions, fuch a one would eafily from the motion of this liquor, folve all the Phænomena, and would not fear to affirm, that it is no obfcure fenfation this Plant hath. But I have faid too much, I humbly fubmit, and am ready to ftand corrected. oj oj I H an grov

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I have not yet made fo full and fatisfactory Observations as I desire on this Plant, which seems to be a Subject that will afford abundance of information.

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information. But as farr as I have had opportunity to examine it, I have difcovered with my *Microfcope* very curious ftructures and contrivances; but defigning much more accurate examinations and trials, both with my *Microfcope*, and otherwife, as foon as the feafon will permit, I fhall not till then add any thing of what I have already taken notice of; but as farr as I have yet obferv'd, I judge the motion of it to proceed from caufes very differing from those by which Gut-ftrings, or Lute-ftrings, the beard of a wilde *Oat*, or the beard of the Seeds of *Geranium*, *Mofcatum*, or *Mnskgrafs* and other of kinds of *Cranes-bill*, move themselves. Of which I shall add more in the fubfequent Obfervations on those bodies.

Observ. XIX. Of a Plant growing in the blighted or yellow specks of Damask-rose-leaves, Bramble-leaves, and some other kind of leaves.

Nature did intend in that poffore, what the does in the lifte feed-cody o

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I Have for feveral years together, in the Moneths of June, July, August, and september (when any of the green leaves of Roses begin to dry and grow yellow) observ'd many of them, especially the leaves of the old shrubs of Damask-Roses, all bespecked with yellow stains, and the underfides just against them, to have little yellow hillocks of a gummous substance, and several of them to have small black spots in the midst of those yellow ones, which, to the naked eye, appear'd no bigger then the point of a Pin, or the smallest black spot or tittle of Ink one is able to make with a very sharp pointed Pen.

Examining these with a Microscope, I was able plainly to diffinguish,up and down the furface, feveral small yellow knobs, of a kind of yellowish red gummy fubstance, out of which I perceiv'd there fprung multitudes of little cafes or black bodies like Seed-cods, and those of them that were quite without the hillock of Gumm, difclos'd themfelves to grow out of it with a small Straw-colour'd and transparent stem, the which feed and ftem appear'd very like those of common Moss (which I elsewhere defcribe) but that they were abundantly lefs, many hundreds of them being not able to equalize one fingle feed Cod of Mofs. I have often doubted whether they were the feed Cods of fome little Plant, or fome kind of fmall Buds, or the Eggs of fome very fmall Infect; they appear'd of a dark brownish red, some almost quite black, and of a Figure much refembling the feed-cod of Mofs, but their stalks on which they grew were of a very fine transparent substance, almost like the stalk of mould, but that they feem'd fomewhat more yellow. That which makes me to suppose them to be Vegetables, is for that I perceiv'd many of those hillocks bare or destitute, as if those bodies lay yet conceal'd, as G. In others of them, they were just fpringing out of their gummy hillocks, which all feem'd to fhoot directly outwards, as at A. In others, as at B, I found them just gotten out, with very little or no stalk, and

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and the Cods of an indifferent cize; but in others, as C, I found them begin to have little flort ftalks, or ftems; in others, as D, those ftems were grown bigger, and larger; and in others, as at E, F, H, I, K, L, $\mathcal{O}c$. those ftems and Cods were grown a great deal bigger, and the ftalks were more bulky about the root, and very much taper'd towards the top, as at F and L is most visible.

I did not find that any of them had any feed in them, or that any of them were hollow, but as they grew bigger and bigger, I found those heads or Cods begin to turn their tops towards their roots, in the fame manner as I had observ'd that of Moss to do; fo that in all likelihood, Nature did intend in that posture, what she does in the like feed-cods of greater bulk, that is, that the seed, when ripe, should be shaken out and dispersed at the end of it, as we find in Columbine Cods, and the like.

The whole Oval OOOO in the fecond Figure of the 12. scheme reprefents a fmall part of a Rofe leaf, about the bignefs of the little Oval in the hillock, C, marked with the Figure X. in which I have not particularly obferv'd all the other forms of the furface of the Rofe-leaf, as being little to my prefent purpofe.

Now, if these Cods have a feed in them so proportion'd to the Cod, as those of *Pinks*, and *Carnations*, and *Columbines*, and the like, how unimaginably small must each of those feeds necessarily be, for the whole length of one of the largest of those Cods was not $\frac{1}{500}$ part of an Inch; some not above $\frac{1}{1000}$, and therefore certainly, very many thousand of them would be unable to make a bulk that should be visible to the naked eye; and if each of these contain the Rudiments of a young Plant of the fame kind, what must we say of the pores and constituent parts of that?

The generation of this Plant feems in part, as for bable to a kind of Mildem or Blight, whereby the parts of the leaves grow scabby, or putrify'd, as it were, so as that the moisture breaks out in little scabs or spots, which, as I faid before, look like little knobs of a red gummous substance.

From this putrify'd fcabb breaks out this little Vegetable; which may be fomewhat like a Mould or Moff, and may have its equivocal generation much after the fame manner as I have fuppofed Mofs or Mould to have, and to be a more fimple and uncompounded kind of vegetation, which is fet a moving by the putrifactive and fermentative heat, joyn'd with that of the ambient aerial, when (by the putrifaction and decay of fome other parts of the vegetable, that for a while staid its progrefs) it is unfetter'd and left at liberty to move in its former courfe, but by reafon of its regulators, moves and acts after quite another manner then it did when a coagent in the more compounded machine of the more perfect Vegetable. And from this very fame Principle, I imagine the Mifleto of Oaks, Thorns, Appletrees, and other Trees, to have its original: It feldom or never growing on any of those Trees, till they begin to wax decrepid, and decay with age, and are pefter'd with many other infirmities. infelt anyt throu Veg tribe anim T on,to flime Eart aWh kind very COVE A are o when and poun curre ratic no a Plan orco kind ing b mina Itano find putra are c cond varia unna Mule unu

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Hither also may be referr d those multitudes and varieties of Mushroms, such as that, call'd Jews-ears, all sorts of gray and green Mosses, &c. which infest

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infeft all kind of Trees, fhrubs, and the like, efpecially when they come to any bignefs. And this we fee to be very much the method of Nature throughout its operations, *putrifactive Vegetables* very often producing a Vegetable of a much lefs compounded nature, and of a much inferiour tribe; and *putrefactive* animal fubftances degenerating into fome kind of animal production of a much inferiour rank, and of a more fimple nature.

Thus we find the humours and fubftances of the body, upon putrifaction, to produce ftrange kinds of moving Vermine : the putrifaction of the flimes and juices of the Stomack and Guts, produce Worms almost like Earth-worms, the Wheals in childrens hands produce a little Worm, call'd a Wheal-worm : The bloud and milk, and other humours, produce other kinds of Worms, at least, if we may believe what is deliver'd to us by very famous Authors; though, I confess, I have not yet been able to difcover such my felf.

And whereas it may feem strange that Vinegar, Meal, musty Casks, &c. are observ'd to breed their differing kinds of Insects, or living creatures, whereas they being Vegetable substances, seem to be of an inferiour kind, and fo unable to produce a creature more noble, or of a more compounded nature then they themselves are of, and so without some concurrent seminal principle, may be thought utterly unfit for fuch an operation; I must add, that we cannot prefently positively fay, there are no animal fubftances, either mediately, as by the foil or fatning of the Plant from whence they fprung, or more immediately, by thereal mixture or composition of such substances, join'd with them; or perchance some kind of Infect, in fuch places where fuch kind of putrifying or fermenting bodies are, may, by a certain inftinct of nature, eject fome fort of feminal principle, which cooperating with various kinds of putrifying fubstances, may produce various kinds of Infects, or Animate bodies : For we find in most forts of those lower degrees of Animate bodies, that the putrifying fubstances on which these Eggs, Seeds, or feminal principles are calt by the Infect, become, as it were, the Matrices or Wombs that conduce very much to their generation, and may perchance allo to their variation and alteration, much after the fame manner, as, by ftrange and unnatural copulations, feveral new kinds of Animals are produc'd, as Mules, and the like, which are ufually call'd Monftrous, becaufe a little unufual, though many of them have all their principal parts as perfectly shap'd and adapted for their peculiar uses, as any of the most perfect Animals. If therefore the putrifying body, on which any kind of feminal or vital principle chances to be caft, become fomewhat more then meerly a nurfing and fostering helper in the generation and production of any kind of Animate body, the more neer it approaches the true nature of a Womb, the more power will it have on the by-blow it incloses. But of this fomewhat more in the description of the Water-gnat. Perhaps fome more accurate Enquiries and Observations about these matters might bring the Question to some certainty, which would be of no small concern in Natural Philosophy. and an and has related on the But that putrifying animal substances may produce animals of an inferior icmmol S 2 kind,

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kind, I fee not any fo very great a difficulty, but that one may, without much absurdity, admit : For as there may be multitudes of contrivances that go to the making up of one compleat Animate body; fo, That fome of those coadjutors, in the perfect existence and life of it, may be vitiated, and the life of the whole deftroyed, and yet feveral of the conftituting contrivances remain intire, I cannot think it beyond imagination or poffibility; no more then that a like accidental process, as I have elswhere hinted, may also be supposed to explicate the method of Nature in the Metamorphofis of Plants. And though the difference between a Plant and an Animal be very great, yet I have not hitherto met with any fo cogent an Argument, as to make me politive in affirming these two to be altogether Heterogeneous, and of quite differing kinds of Nature: And besides, as there are many Zoophyts, and fenfitive Plants (divers of which I have feen, which are of a middle nature, and feem to be Natures transition from one degree to another, which may be observ'd in all her other passages, wherein she is very feldom observ'd to leap from one step to another) so have we, in fome Authors, Inftances of Plants turning into Animals, and Animals into Plants, and the like; and fome other very ftrange (becaufe unheeded) proceedings of Nature; fomething of which kind may be met with, in the description of the Water-Gnat, though it be not altogether so direct to the prefent purpofe.

But to refer this Discourse of Animals to their proper places, I shall add, that though one fhould suppose, or it should be prov'd by Observations, that feveral of these kinds of Plants are accidentally produc'd by a eafual putrifaction, I fee not any great reason to question, but that, notwithstanding its own production was as 'twere casual, yet it may germinate and produce feed, and by it propagate its own, that is, a new Species. For we do not know, but that the Omnipotent and All-wife Creator might as directly defign the structure of such a Vegetable, or such an Animal to be produc'd out of fuch or fuch a putrifaction or change of this or that body, towards the conftitution or ftructure of which, he knew it necessary, or thought it fit to make it an ingredient; as that the digeftion or moderate heating of an Egg, either by the Female, or the Sun, or the heat of the Fire, or the like, should produce this or that Bird; or that Putrifactive and warm steams should, out of the blowings, as they call them, that is, the Eggs of a Flie, produce a living Magot, and that, by degrees, be turn'd into an Aurelia, and that, by a longer and a proportion'd heat, be transmuted into a Fly. Nor need we therefore to suppose it the more imperfect in its kind, then the more compounded Vegetable or Animal of which it is a part; for he might as compleatly furnish it with all kinds of contrivances neceffary for its own existence, and the propagation of its own Species, and yet make it a part of a more compounded body: as a Clock-maker might make a Set of Chimes to be a part of a Clock, and yet, when the watch part or firiking part are taken away, and the hindrances of its motion remov'd, this chiming part may go as accurately, and strike its tune as exactly, as if it were still a part of the compounded Automaton. So, though the original caufe, or feminal

hout inces fome ated, uting offibi-nted, mor-Ani-n Ar-ether there vhich egree n fhe we, in sinto ded) th, in there f fhall ferva-d by a not-ermi-pecies. reator ich an nge of ch, he at the or the Bird; s they hat,by





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feminal principle from which this minute Plant on Rofe leaves did fpring, were, before the corruption caus'd by the Mill-dew, a component part of the leaf on which it grew, and did ferve as a coagent in the production and conftitution of it, yet might it be fo confummate, as to produce a feed which might have a power of propagating the fame fpecies: the works of the Creator feeming of fuch an excellency, that though they are unable to help to the perfecting of the more compounded existence of the greater Plant or Animal, they may have notwithstanding an ability of acting fingly upon their own internal principle, fo as to produce a Vegetable body, though of a lefs compounded nature, and to proceed fo farr in the method of other Vegetables, as to bear flowers and feeds, which may be capabale of propagating the like. So that the little cafes which appear to grow on the top of the flender stalks, may, for ought I know, though I fhould suppose them to spring from the perverting of the usual course of the parent Vegetable, contain a feed, which, being fcatter'd on other leaves of the fame Plant, may produce a Plant of much the fame kind.

Nor are Damafk-Rofe leaves the onely leaves that produce thefe kinds of Vegetable foroutings; for I have obferv'd them alfo in feveral other kinds of Rofe leaves, and on the leaves of feveral forts of Briers, and on Bramble leaves they are oftentimes to be found in very great elufters; fo that I have found in one clufter, three, four, or five hundred of them, making a very confpicuous black for or feab on the back fide of the leaf.

Observ. X X. Of blue Mould, and of the first Principles of Vegetation arising from Putrefaction.

THe Blue and White and feveral kinds of hairy mouldy fpots, which are observable upon divers kinds of putrify'd bodies, whether Animal fubstances, or Vegetable, such as the skin, raw or dress'd, flesh, bloud, humours, milk, green Cheefe, Ge. or rotten fappy Wood, or Herbs, Leaves, Barks, Roots, Oc. of Plants, are all of them nothing elfe but feveral kinds of fmall and varioufly figur'd Mufhroms, which, from convenient materials in those putrifying bodies, are, by the concurrent heat of the Air, excited to a certain kind of vegetation, which will not be unworthy our more ferious speculation and examination, as I shall by and by thew. But, first, I must premise a thort description of this specimen, which I have added of this Tribe, in the first Figure of the XII. scheme, which is nothing elfe but the appearance of a fmall white fpot of hairy mould, multitudes of which I found to befpeck & whiten over the red covers of a fmall book, which, it feems, were of Sheeps-fkin, that being more apt to gather mould, even in a dry and clean room, then other leathers. These spots appear'd, through a good Microscope, to be a very pretty shap'd Vegetative body, which, from almost the same part of the Leather, shot DUE

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out multitudes of small long cylindrical and transparent stalks, not exactly streight, but a little bended with the weight of a round and white knob that grew on the top of each of them; many of these knobs I observ'd to be very round, and of a smooth surface, such as A A, O.c. others smooth likewife, but a little oblong, as B; feveral of them a little broken, or cloven with chops at the top, as C; others flitter'd as 'twere, or flown all to pieces, as D D. The whole substance of these pretty bodies was of a very tender conftitution, much like the fubstance of the fofter kind of common white Mushroms, for by touching them with a Pin, I found them to be brused and torn; they seem'd each of them to have a diftinct root of their own; for though they grew neer together in a clufter, yet I could perceive each ftem to rife out of a diffinct part or pore of the Leather; fome of these were small and short, as seeming to have been but newly fprung up, of these the balls were for the most part round, others were bigger, and taller, as being perhaps of a longer growth, and of thefe, for the most part, the heads were broken, and some much wasted, as E; what these heads contain'd I could not perceive; whether they were knobs and flowers, or feed cafes, I am not able to fay, but they feem'd most likely to be of the fame nature with those that grow on Mushroms, which they did, fome of them, not a little refemble.

Both their fmell and tafte, which are active enough to make a fenfible impreffion upon those organs, are unpleasant and noisome.

I could not find that they would fo quickly be deftroy'd by the actual flame of a Candle, as at first fight of them I conceived they would be, but they remain'd intire after I had pass that part of the Leather on which they stuck three or four times through the flame of a Candle; so that, it feems they are not very apt to take fire, no more then the common white Mushroms are when they are stappy.

There are a multitude of other shapes, of which these Microscopical Mushroms are figur'd, which would have been a long Work to have defcribed, and would not have fuited fo well with my defign in this Treatife, onely, amongst the rest, I must not forget to take notice of one that was a little like to, or refembled, a Spunge, confifting of a multitude of little Ramifications almost as that body does, which indeed feems to be a kind of Water-Mulhrom, of a very pretty texture, as I elfe-where manifest. And a fecond, which I must not omit, because often mingled, and neer adjoining to these I have describ'd, and this appear'd much like a Thicket of bufhes, or brambles, very much branch'd, and extended, fome of them, to a great length, in proportion to their Diameter, like creeping brambles. The manner of the growth and formation of this kind of Vegetable, is the third head of Enquiry, which, had I time, I thould follow : the figure and method of Generation in this concrete feeming to me, next after the Enquiry into the formation, figuration, or chrystalization of Salts, to be the most fimple, plain, and easie; and it seems to be a medium through which he must necessarily pass, that would with any likelihood investigate the forma informans of Vegetables : for as I think that he shall find it a very difficult talk, who undertakes to discover the form of Saline

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line cryftallizations, without the confideration and prefeience of the nature and reafon of a Globular form, and as difficult to explicate this configuration of Mufhroms, without the previous confideration of the form of Salts; fo will the enquiry into the forms of Vegetables be no lefs, if not much more difficult, without the fore-knowledge of the forms of Mufhroms, these feveral Enquiries having no lefs dependance one upon another then any felect number of Propositions in Mathematical Elements may be made to have.

Nor do I imagine that the fkips from the one to another will be found very great, if beginning from fluidity, or body without any form, we defeend gradually, till we arrive at the higheft form of a bruite Animal's Soul, making the fteps or foundations of our Enquiry, *Fluidity*, Orbiculation, Fixation, Angulization, or Cryftallization Germination or Ebullition, Vegetation, Plantanimation, Animation, Senfation, Imagination.

Now, that we may the better proceed in our Enquiry, It will be requifite to confider :

First, that Mould and Mushroms require no feminal property, but the former may be produc'd at any time from any kind of putrifying Animal, or Vegetable Substance, as Flesh, O.c. kept moist and warm, and the latter, if what Mathiolus relates be true, of making them by Art, are as much within our command, of which Matter take the Epitomie which Mr. Parkinson has deliver'd in his Herbal, in his Chapter of Mushroms, because I have not Mathiolus now by me : Unto these Mushroms (faith he) may alfo be adjoyn'd those which are made of Art (whereof Mathiolus makes mention) that grow naturally among certain fiones in Naples, and that the ftones being digg'd up, and carried to Rome, and other places, where they fet them in their Wine Cellars, covering them with a little Earth, and fprinkling a little warm water thereon, would within four days produce Mushroms fit to be eaten, at what time one will: As also that Mushroms may be made to grow at the foot of a wilde Poplar Tree, within four days after, warm water wherein some leaves have been diffolv'd shall be pour'd into the Root (which must be slit) and the stock above ground.

Next, that as Mußhroms may be generated without feed, fo does it not appear that they have any fuch thing as feed in any part of them; for having confidered feveral kinds of them, I could never find any thing in them that I could with any probability ghess to be the feed of it, fo that it does not as yet appear (that I know of) that Mushroms may be generated from a feed, but they rather feem to depend merely upon a convenient conftitution of the matter out of which they are made, and a concurrence of either natural or artificial heat. Thirdly, that by feveral bodies (as Salts and Metals both in Water and in the air, and by feveral kinds of fublimations in the Air) actuated and guided with a congruous heat, there may be produc'd feveral kinds of bodies as curioully, if not of a more compos'd Figure ; feveral kinds of rifing or Ebulliating Figures feem to manifeft; as witness the flooting in the Rectification of fpirits of Urine, Hart-horn, Bloud, &c. witness alfo the curious branches of evaporated diffolutions, fome of them against the

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the fides of the containing Jar: others ftanding up, or growing an end, out of the bottom, of which I have taken notice of a very great variety. But above all the reft, it is a very pretty kind of Germination which is afforded us in the Silver Tree, the manner of making which with Mercury and Silver, is well known to the Chymifts, in which there is an Ebullition or Germination, very much like this of Mufhroms, if I have been rightly inform'd of it.

Fourthly, I have very often taken notice of, and alfo obferv'd with a *Microfcope*, certain excrefcencies or Ebullitions in the fnuff of a Candle, which, partly from the fticking of the fmoaky particles as they are carryed upwards by the current of the rarify'd Air and flame, and partly alfo from a kind of Germination or Ebullition of fome actuated unctuous parts which creep along and filter through fome fmall ftring of the Week, are formed into pretty round and uniform heads, very much refembling the form of hooded Mufhroms, which, being by any means expos'd to the frefh Air, or that air which encompafies the flame, they are prefently lick'd up and devour'd by it, and vanifh.

The reason of which Phanomenon seems to me, to be no other then this :

That when a convenient thread of the Week is fo bent out by the fides of the fnuff that are about half an Inch or more, remov'd above the bottom, or lowest part of the flame, and that this part be wholly included in the flame; the Oyl (for the reason of filtration, which I have elsewhere rendred) being continualy driven up the fnuff, is driven likewife into this ragged bended-end, and this being remov'd a good distance, as half an Inch or more, above the bottom of the flame, the parts of the air that passes by it, are already, almost fatiated with the diffolution of the boiling uncluous steams that issued out below, and therefore are not onely glutted, that is, can diffolve no more then what they are already acting upon, but they carry up with them abundance of unctuous and footy particles, which meeting with that rag of the Week, that is plentifully fill'd with Oyl, and onely spends it as fast as it evaporates, and not at all by diffolution or burning, by means of these steamy parts of the filterated Oyl isluing out at the fides of this ragg, and being inclos'd with an air that is already fatiated and cannot prey upon them nor burn them, the alcending footy particles are ftay'd about it and fix'd, lo as that about the end of that ragg or filament of the fnuff, whence the greatest part of the steams issue, there is conglobated or fix'd a round and pretty uniform cap, much refembling the head of a Mushrom, which, if it be of any great bigness, you may observe that its underfide will be bigger then that which is above the ragg or frem of it; for the Oyl that is brought into it by filtration, being by the bulk of the cap a little shelter'd. from the heat of the flame, does by that means iffue as much out from beneath from the stalk or downwards, as it does upwards, and by reason of the great accels of the adventitious fmoak from beneath, it increases most that way. That this may be the true reason of this Phanomenon, I could produce many Arguments and Experiments to make it probable: As, First, that the Filtration carries the Oyl to the top of the Week, at least

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as high as these raggs, is visible to one that will observe the souff of a burning Candle with a *Microscope*, where he may see an Ebullition or bubbling of the Oyl, as high as the souff looks black.

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Next, that it does fteam away more then burn; I could tell you of the dim burning of a Candle, the longer the fnuff be which arifes from the abundance of vapours out of the higher parts of it.

And, thirdly, that in the middle of the flame of the Candle, neer the top of the fnuff, the fire or diffolving principle is nothing neer fo ftrong, as neer the bottom and out edges of the flame, which may be observed by the burning afunder of a thread, that will first break in those parts that the edges of the flame touch, and not in the middle.

And I could add feveral Observables that I have taken notice of in the flame of a Lamp actuated with Bellows, and very many others that confirm me in my opinion, but that it is not fo much to my present purpose, which is onely to confider this concrect in the souff of a Candle, so farr as it has any resemblance of a Mushrom, to the confideration of which, that I may return, I fay, we may also observe:

In the first place, that the droppings or trillings of Lapidescent waters in Vaults under ground, seem to constitute a kind of petrify'd body, form'd almost like fome kind of Mushroms inverted, in fo much that I have feen fome knobb'd a little at the lower end, though for the most part, indeed they are otherwife fhap'd, and taper'd towards the end; the generation of which feems to be from no other reafon but this, that the water by foaking through the earth and Lime (for I ghess that substance to add much to it petrifying quality) does fo impregnate it felf with ftony particles, that hanging in drops in the roof of the Vault, by reafon that the foaking of the water is but flow, it becomes expos'd to the Air, and thereby the outward part of the drop by degrees grows hard, by reason that the water gradually evaporating the frony particles neer the outfides of the drop begin to touch, and by degrees, to dry and grow closer together, and at length conftitute a cruft or shell about the drop; and this foaking by degrees, being more and more fupply'd, the drop grows longer and longer, and the fides harden thicker and thicker into a Quill or Cane, and at length, that hollow or pith becomes almost ftop'd up, and folid: afterwards the foaking of the petrifying water, finding no longer a paffage through the middle, burfts out, and trickles down the outfide, and as the water evaporates, leaves new superinduc'd shells, which more and more fwell the bulk of those Iceicles; and because of the great fupply from the Vault, of petrifying water, those bodies grow bigger and bigger next to the Vault, and taper or fharpen towards the point; for the access from the arch of the Vault being but very flow, and confequently the water being fpread very thinly over the furface of the Iceicle, the water begins to fettle before it can reach to the bottom, or corner end of it; whence, if you break one of thefe, you would almost imagine it a flick of Wood petrify'd, it having fo pretty a refemblance of pith and grain, and if you look on the outfide of a piece, or of one whole, you would think no lefs, both from its vegetable roundnefs and tapering

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tapering form; but whereas all Vegetables are observ'd to shoot and grow perpendicularly upwards, this does shoot or propend directly downwards.

By which laft Obfervables, we fee that there may be a very pretty body fhap'd and concreted by Mechanical principles, without the leaft fhew or probability of any other feminal *formatrix*.

And fince we find that the great reafon of the *Phænomena* of this pretty *petrifation*, are to be reduc'd from the gravity of a fluid and pretty volatil body impregnated with ftony particles, why may not the *Phænomena* of Ebullition or Germination be in part poffibly enough deduc'd from the levity of an impregnated liquor, which therefore perpendicularly afcending by degrees, evaporates and leaves the more folid and fix'd parts behind in the form of a Mufhrom, which is yet further diverfify'd and specificated by the forms of the parts that impregnated the liquor, and compose or help to conftitute the Mufhrom.

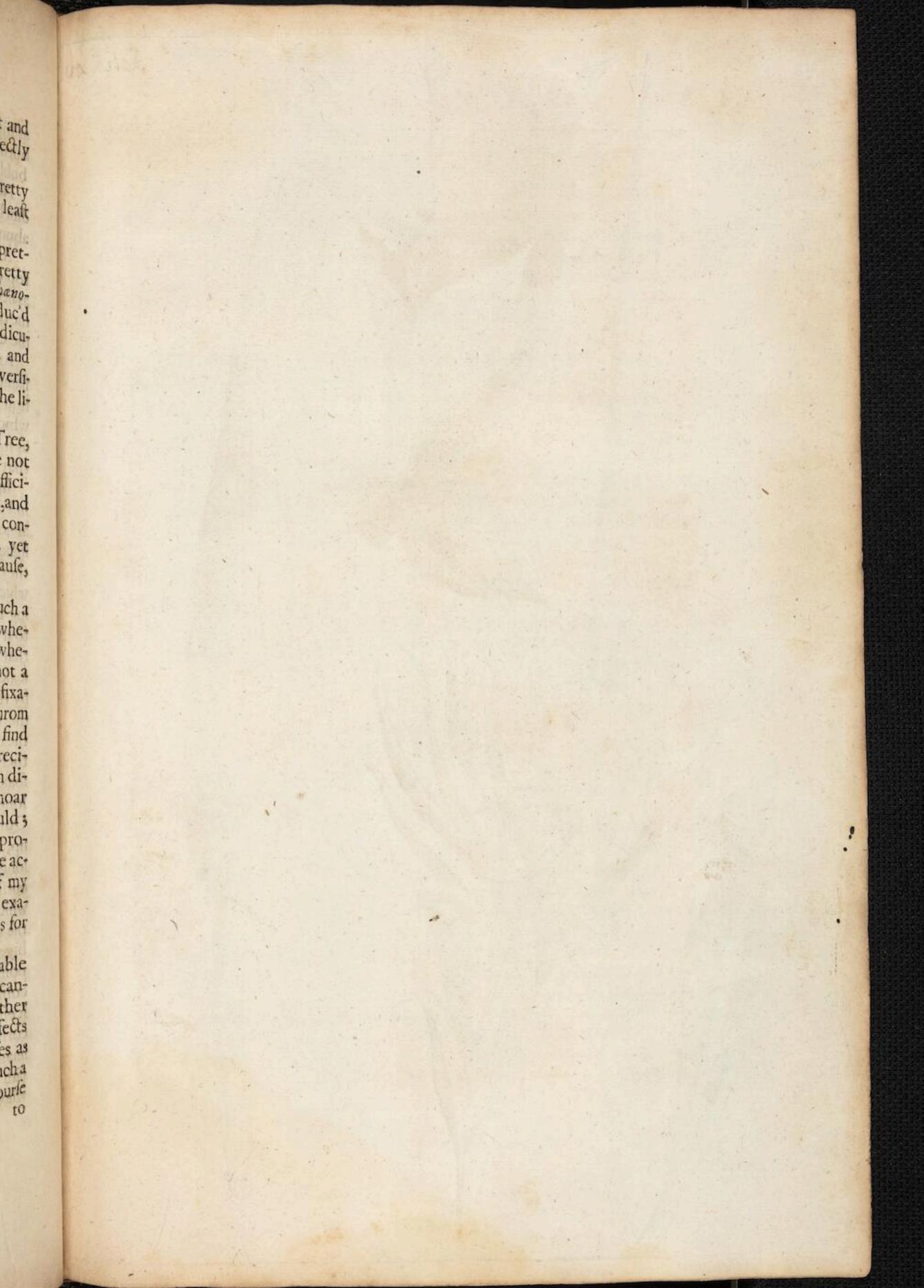
That the foremention'd Figures of growing Salts, and the Silver Tree, are from this principle, I could very eafily manifeft; but that I have not now a convenient opportunity of following it, nor have I made a fufficient number of Experiments and Obfervations to propound, explicate, and prove fo ufefull a *Theory* as this of Mufhroms: for, though the contrary principle to that of *petrify'd* Iceicles may be in part a caufe; yet I cannot but think, that there is fomewhat a more complicated caufe, though yet Mechanical, and poffible to be explain'd.

We therefore have further to enquire of it, what makes it to be fuch a liquor, and to alcend, whether the heat of the Sun and Air, or whether that of firmentiation and putrifaction, or both together; as also whether there be not a third or fourth; whether a Saline principle be not a confiderable agent in this bufiness also as well as heat; whether also a fixation, precipitation or fettling of certain parts out of the aerial Mushrom may not be also a confiderable coadjutor in the business. Since we find that many pretty beards or stirie of the particles of Silver may be precipitated upon a piece of Brass put into a folution of Silver very much diluted with fair water, which look not unlike a kind of mould or hoar upon that piece of metal; and the hoar frost looks like a kind of mould; and whether there may not be feveral others that do concurr to the production of a Mufhrom, having not yet had fufficient time to profecute according to my defires. I must referr this to a better opportunity of my own, or leave and recommend it to the more diligent enquiry and examination of fuch as can be mafters both of leifure and conveniencies for fuch an Enquiry. And in the mean time, I must conclude, that as far as I have been able to look into the nature of this Primary kind of life and vegetation, I cannot find the least probable argument to perfwade me there is any other concurrent caufe then fuch as is purely Mechanical, and that the effects or productions are as neceffary upon the concurrence of those causes as that a Ship, when the Sails are hoift up, and the Rudder is fet to fuch a polition, should, when the Wind blows, be mov'd in fuch a way or course

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to that or t'other place; Or, as that the brufed Watch, which I mention in the defeription of Mofs, fhould, when those parts which hindred its motion were fallen away, begin to move, but after quite another manner then it did before.

cent) (cent'd full of exceeding finall white feeds, much like the feed-have

in the knop of a Carnation, after the flowers have been two or through

Observ. XX1. Of Moss, and several other small vegetative Substances.

Moss is a Plant, that the wifest of Kings thought neither unworthy his speculation, nor his Pen, and though amongst Plants it be in bulk one of the smallest, yet it is not the least confiderable: For, as to its shape, it may compare for the beauty of it with any Plant that grows, and bears a much bigger breadth; it has a root almost like a feedy Parfnep, furnish'd with small strings and suckers, which are all of them finely branch'd, like those of the roots of much bigger Vegetables; out of this fprings the ftem or body of the Plant, which is fomewhat Quadrangular, rather then Cylindrical, most curiously fluted or strung with small creases, which run, for the most part, parallel the whole stem; on the sides of this are close and thick fet, a multitude of fair, large, well-shap'd leaves, some of them of a rounder, others of a longer shape, according as they are younger or older when pluck'd; as I ghess by this, that those Plants that had the stalks growing from the top of them, had their leaves of a much longer shape, all the surface of each fide of which, is curiously cover'd with a multitude of little oblong transparent bodies, in the manner as you fee it express'd in the leaf B, in the XIII. Scheme.

This Plant, when young and fpringing up, does much refemble a Houfleek, having thick leaves, almost like that, and seems to be somwhat of kin to it in other particulars; also from the top of the leaves, there shoots out a small white and transparent hair, or thorn: This stem, in time, come to fhoot out into a long, roundand even stalk, which by cutting transversly, when dry, I manifeftly found to be a ftiff, hard, and hollow Cane, or Reed, without any kind of knot, or ftop, from its bottom, where the leaves encompass'd it, to the top, on which there grows a large feed cafe, A, cover'd with a thin, and more whitifh fkin, B, terminated in a long thorny top, which at first covers all the Cafe, and by degrees, as that fwells, the fkin cleaves, and at length falls off, with its thorny top and all (which is a part of it) and leaves the feed Cafe to ripen, and by degrees, to shatter out its feed at a place underneath this cap, B, which before the feed is ripe, appears like a flat barr'd button, without any hole in the middle; but as it ripens, the button grows bigger, and a hole appears in the middle of it, E, out of which, in all probability, the feed falls: For as it ripens by a provision of Nature, that end of this Cafe turns downward after the fame manner as the ears of Wheat and Barley ufually do; and opening feveral of these dry red Cases, F, I found them to be billy little noicest Din ing. Tchit was rooted.

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quite hollow, without any thing at all in them; whereas when I cut them afunder with a fharp Pen-knife when green, I found in the middle of this great Cafe, another fmaller round Cafe, between which two, the *interflices* were fill'd with multitudes of ftringie *fibres*, which feem'd to fufpend the leffer Cafe in the middle of the other, which (as farr as I was able to difcern) feem'd full of exceeding fmall white feeds, much like the feed-bagg in the knop of a Carnation, after the flowers have been two or three days, or a week, fallen off; but this I could not fo perfectly difcern, and therefore cannot pofitively affirm it.

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After the feed was fallen away, I found both the Cafe, Stalk, and Plant, all grow red and wither, and from other parts of the root continually to fpring new branches or flips, which by degrees increased, and grew as bigg as the former, feeded, ripen'd, fhatter'd, and wither'd.

I could not find that it observ'd any particular seafons for these several kinds of growth, but rather found it to be springing, mature, ripe, seedy, and wither'd at all times of the year; But I found it most to flourish and increase in warm and moss weather.

It gathers its nourifhments, for the most part, out of some Lapidescent, or other substance corrupted or chang'd from its former texture, or substantial form; for I have found it to grow on the rotten parts of Stone, of Bricks, of Wood, of Bones, of Leather, &c.

It oft grows on the barks of feveral Trees, fpreading it felf, fometimes from the ground upwards, and fometimes from fome chink or cleft of the bark of the Tree, which has fome *putrify*'d fubftance in it; but this feems of a diffinct kind from that which I observ'd to grow on *putrify*'d inanimate bodies, and rotten earth.

There are also great varieties of other kinds of Moss, which grow on Trees, and several other Plants, of which I shall here make no mention, nor of the Moss growing on the skull of a dead man, which much resembles that of Trees.

Whether this Plant does fometimes originally fpring or rife out of corruption, without any diffeminated feed, I have not yet made trials enough to be very much, either positive or negative; for as it seems very hard to conceive how the feed should be generally dispers'd into all parts where there is a corruption begun, unlefs we may rationally fuppofe, that this feed being fo exceeding fmall, and confequently exceeding light, is thereby taken up, and carried to and fro in the Air into every place, and by the falling drops of rain is wash'd down out of it, and so dispers'd into all places, and there onely takes root and propagates, where it finds a convenient foil or matrix for it to thrive in; fo if we will have it to proceed from corruption, it is not lefs difficult to conceive, First, how the corruption of any Vegetable, much lefs of any Stone or Brick, should be the Parent of so curiously figur'd, and so perfect a Plant as this is. But here indeed, I cannot but add, that it feems rather to be a product of the Rain in those bodies where it is stay'd, then of the very bodies themfelves, fince I have found it growing on Marble, and Flint; but always the Microscope, if not the naked eye, would discover fome little hole of Dirt in which it was rooted. Next,

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Next, how the corruption of each of those exceedingly differing bodies fhould all confpire to the production of the fame Plant, that is, that Stones, Bricks, Wood, or vegetable fubftances, and Bones, Leather, Horns, or animate fubftances, unless we may with fome plaufiblencies fay, that Air and Water are the coad jutors, or *menstruums*, in all kinds of *putrifactions*, and that thereby the bodies (though whil'ft they retain'd their fubftantial forms, were of exceeding differing natures, yet) fince they are diffolv'd and mixt into another, they may be very *Homogeneous*, they being almost refolv'd again into Air, Water, and Earth 3 retaining, perhaps, one part of their vegetative faculty yet entire, which meeting with congruous affiftants, fuch as the heat of the Air, and the fluidity of the Water, and fuch like coad jutors and conveniences, acquires a certain vegetation for a time, wholly differing perhaps from that kind of vegetation it had before.

To explain my meaning a little better by a groß Similitude :

Suppose a curious piece of Clock-work, that had had feveral motions and contrivances in it, which, when in order, would all have mov'd in their defign'd methods and Periods. We will further fuppofe, by fome means, that this Clock comes to be broken, brused, or otherwise difordered, fo that feveral parts of it being diflocated, are impeded, and fo ftand ftill, and not onely hinder its own progressive motion, and produce not the effect which they were defign'd for, but because the other parts alfo have a dependence upon them, put a ftop to their motion likewife; and fo the whole Inftrument becomes unferviceable,, and not fit for any ufe. This Inftrument afterwards, by fome fhaking and tumbling, and throwing up and down, comes to have feveral of its parts shaken out, and feveral of its curious motions, and contrivances, and particles all fallen afunder; here a Pin falls out, and there a Pillar, and here a Wheel, and there a Hammer, and a Spring, and the like, and among the reft, away falls those parts also which were brused and disorder'd, and had all this while impeded the motion of all the reft; hereupon feveral of those other motions that yet remain, whole springs were not quite run down, being now at liberty, begin each of them to move, thus or thus, but quite after another method then before, there being many regulating parts and the like, fallen away and loft. Upon this, the Owner, who chances to hear and observe some of these effects, being ignorant of the Watch-makers Art, wonders what is betid his Clock, and prefently imagines that fome Artift has been at work, and has fet his Clock in order, and made a new kind of Instrument of it, but upon examining circumstances, he finds there was no fuch matter, but that the cafual flipping out of a Pin had made feveral parts of his Clock fall to pieces, and that thereby the obstacle that all this while hindred his Clock, together with other usefull parts were fallen out, and fo his Clock was fet at liberty. And upon winding up those springs again when run down, he finds his Clock to go, but quite after another manner then it was wont heretofore. And thus may it be perhaps in the business of Moss and Mould, and Mußhroms, and feveral other spontaneous kinds of vegetations, which may

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may be caus d by a vegetative principle, which was a coadjutor to the life and growth of the greater Vegetable, and was by the deftroying of the life of it ftopt and impeded in performing its office; but afterwards, upon a further corruption of feveral parts that had all the while impeded it, the heat of the Sun winding up, as it were, the fpring, fets it again into a vegetative motion, and this being fingle, and not at all regulated as it was before(when a part of that greater *machine* the priftine vegetable) is mov'd after quite a differing manner, and produces effects very differing from those it did before.

But this I propound onely as a conjecture, not that I am more enclin'd to this Hypothesis then the seminal, which upon good reason 1 ghess to be Mechanical alfo, as I may elfewhere more fully fhew : But becaufe I may, by this, hint a poffible way how this appearance may be folv'd; supposing we should be driven to confess from certain Experiments and Observations made, that fuch or fuch Vegetables were produc'd out of the corruption of another, without any concurrent feminal principle (as I have given some reason to suppose, in the description of a Microfcopical Mushrome) without derogating at all from the infinite wildom of the Creator. For this accidental production, as I may call it, does manifest as much, if not very much more, of the excellency of his contrivance as any thing in the more perfect vegetative bodies of the world, even as the accidental motion of the Automaton does make the owner fee, that there was much more contrivance in it then at first he imagin'd. But of this I have added more in the defeription of Mould, and the Vegetables on Rofe leaves, &c. those being much more likely to have their original from fuch a cause then this which I have here described, in the 13. Scheme, which indeed I cannot conceive otherwife of, then as of a most perfect Vegetable, wanting nothing of the perfections of the most conspicuous and vastest Vegetables of the world, and to be of a rank fo high, as that it may very properly be reckon'd with the tall Cedar of Lebanon, as that Kingly Botanist has done.

We know there may be as much curiofity of contrivance, and excellency of form in a very fmall Pocket-clock, that takes not up an Inch fquare of room, as there may be in a Church-clock that fills a whole room ; And I know not whether all the contrivances and Mechanifms requifite to a perfect Vegetable, may not be crowded into an exceedingly lefs room then this of Mofs, as I have heard of a striking Watch fo small, that it ferv'd for a Pendant in a Ladies ear; and I have already given you the description of a Plant growing on Rose leaves, that is abundantly smaller then Moss; infomuch, that neer 1000. of them would hardly make the bignefs of one fingle Plant of Mofs. And by comparing the bulk of Mols, with the bulk of the biggeft kind of Vegetable we meet with in Story (of which kind we find in fome hotter climates, as Guine, and Brasile, the stock or body of some Trees to be twenty foot in Diameter, whereas the body or ftem of Mofs, for the most part, is not above one fixtieth part of an Inch) we shall find that the bulk of the one will exceed the bulk of the other, no lefs then 2985984 Millions, OF

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135 or 2985984000000, and supposing the production on a Rose leaf to be a Plant, we shall have of those Indian Plants to exceed a production of the fame Vegetable kingdom no lefs then 1000 times the former number 3 fo prodigioufly various are the works of the Creator, and fo All-fufficient is he to perform what to man would feem unpoffible, they being both alike cafie to him, even as one day, and a thousand years are to him as one and the fame time.

I have taken notice of fuch an infinite variety of those smaller kinds of vegetations, that flould I have defcribed every one of them, they would almost have fill'd a Volume, and prov d bigg enough to have made a new Herbal, fuch multitudes are there to be found in moift hot weather, efpecially in the Summer time, on all kind of putrifying fubftances, which, whether they do more properly belong to the Claffis of Musbroms, or Moulds, or Mosses, I shall not now dispute, there being some that seem more properly of one kind, others of another, their colours and magnitudes being as much differing as their Figures and fubftances.

Nay, I have observ'd, that putting fair Water (whether Rain-water or Pump-water, or May-dem, or Snow-water, it was almost all one) I have often observ'd, I fay, that this Water would, with a little standing, tarnish and cover all about the fides of the Glass that lay under water, with a lovely green; but though I have often endeavour'd to discover with my Microscope whether this green were like Moss, or long striped Sea-weed, or any other peculiar form, yet so ill and imperfect are our Microscopes, that I could not certainly diferiminate any.

Growing Trees alfo, and any kinds of Woods, Stones, Bones, &c. that have been long expos d to the Air and Rain, will be all over cover'd with a greenith fcurff, which will very much foul and green any kind of cloaths that are rubb'd against it; viewing this, I could not certainly perceive in many parts of it any determinate form, though in many I could perceive a Bed as 'twere of young Mofs, but in other parts it look'd almost like green bushes, and very confus'd, but always of what ever irregular Figures the parts appear'd of, they were always green, and feem'd to be either fome Vegetable, or to have fome vegetating principle.

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Observ. XXII. Of common Sponges, and several other Spongie fibrous bodies. g the

Sponge is commonly reckon'd among the Zoophyts, or Plant Animals; and the texture of it, which the Microfcope discovers, feems to confirm it; for it is of a form whereof I never observ'd any other Vegetable, and indeed, it feems impossible that any should be of it, for it confilts of an infinite number of small short fibres, or nervous parts, much of the same bigness, curiously jointed or contex'd together in the form of a Net, as is more plainly manifest by the little Draught which I have added

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added, in the third Figure of the IX. scheme, of a piece of it, which you may perceive reprefents a confus'd heap of the fibrous parts curioufly jointed and implicated. The joints are, for the most part, where three fibres onely meet, for I have very feldom met with any that had four. At these joints there is no one of the three that seems to be the stock

At thele joints there is no one of the *fibres* are, for the most part, of whereon the other grow, but each of the *fibres* are, for the most part, of an equal bignels, and seem each of them to have an equal share in the joint; the *fibres* are all of them much about the same bignels, not smaller towards the top of the Sponge, and bigger neerer the bottom or root, as is usuall in Plants, the length of each between the joints, is very irregular and different; the distance between some two joints, being ten or twelve times more then between some others.

Nor are the joints regular, and of an *equitriagonal Figure*, but, for the most part, the three *fibres* io meet, that they compose three angles very differing all of them from one another.

The mefhes likewife, and holes of this reticulated body, are not lefs various and irregular: fome *bilateral*, others *trilateral*, and *quadrilateral* Figures; nay, I have obferv'd fome mefhes to have 5, 6, 7, 8, or 9. fides, and fome to have onely one, fo exceeding various is the *Lufus Nature* in this body.

As to the outward appearance of this Vegetative body, they are fo ufuall every where, that I need not defcribe them, confifting of a foft and porous fubftance, reprefenting a Lock, fometimes a fleece of Wooll; but it has befides these fmall *microfcopical* pores which lie between the *fibres*, a multitude of round pores or holes, which, from the top of it, pierce into the body, and fometimes go quite through to the bottom.

I have obferv'd many of these Sponges, to have included likewise in the midft of their fibrous contextures, pretty large friable stones, which must either have been inclos'd whil'st this Vegetable was in formation, or generated in those places after it was perfectly shap'd. The later of which seems the more improbable, because I did not find that any of these story fubstances were perforated with the *fibres* of the Sponge.

I have never seen nor been enform'd of the true manner of the growing of Sponges on the Rock; whether they are found to increase from little to great, like Vegetables, that is, part after part, or like Animals, all parts equally growing together; or whether they be matrices or feed-baggs of any kind of Fishes, or some kind of watry Infect; or whether they are at any times more foft and tender, or of another nature and texture, which things, if I knew, I should much defire to be informed of: but from a curfory view that I at first made with my Microscope, and some other trials,I supposed it to be some Animal substance cast out, and fastned upon the Rocks in the form of a froth, or congeries of bubbles, like that which I have often observ'd on Rosemary, and other Plants (wherein is included a little Infect) that all the little films which divide thefe bubbles one from another, did prefently, almost after the substance began to grow a little harder, break, and leave onely the thread behind, which might be, as 'twere, the angle or thread between the bubbles, that the great

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great holes or pores observable in these Sponges were made by the eruption of the included Heterogeneous substance (whether air, or some other body, for many other fluid bodies will do the fame thing) which breaking out of the leffer, were collected into very large bubbles, and fo might make their way out of the Sponge, and in their paflage might leave a round cavity; and if it were large, might carry up with it the adjacent bubbles, which may be perceiv'd at the outfide of the Sponge, if it be first throughly wetted, and suffer'd to plump it self into its natural form, or be then wrung dry, and fuffer'd to expand it felf again, which it will freely do whil'ft moift : for when it has thus plump'd it felf into its natural shape and dimensions, 'tis obvious enough that the mouths of the larger holes have a kind of lip or rifing round about them, but the other fmaller pores have little or none. It may further be found, that each of thefe great pores has many other fmall pores below, that are united unto it, and help to conftitute it, almost like so many rivulets or small streams that contribute to the maintenance of a large River. Nor from this Hypothesis would it have been difficult to explicate, how those little branches of Coral, fmal Stones, shells, and the like, come to be included by thefe frothy bodies : But this inded was but a conjecture ; and upon a more accurate enquiry into the form of it with the Microscope, it feems not to be the true origine of them; for whereas Sponges have onely three arms which join together at each knot, if they had been generated from bubbles they must have had four.

But that they are Animal Substances, the Chymical examination of them feems to manifest, they affording a volatil Salt and spirit, like Harts-Horn, as does also their great strength and toughness, and their smell when burn'd in the Fire or a Candle, which has a kind of flefhy fent, not much unlike to hair. And having fince examin'd feveral Authors concerning them, among others, I find this account given by Bellonius, in the X I. Chap. of his 2d Book, De Aquatilibus. Spongiæ recentes, fays he, à ficcis longe diverse, scopulis aqua marina ad duos vel tres cubitos, nonnunquam quatuor tantum digitos immersis, ut sungi arboribus adhærent, sordido quodam succo aut mucosa potius sanie refærtæ,usque adeo fætida.ut vel eminus nauseam excitet, continetur autem is cavernis, quas inanes in ficcis & lotis Spongiis cernimus : Putris pulmonis modo nigra conspiciuntur, verum qua in sublimi aquæ nascuntur multo magis opaca nigredine suffusæ sunt. Vivere quidem Spongias adharendo Aristoteles censet : absolute vero minime : sensumque aliquem habere, vel eo argumento (inquit) credantur, quod difficillime abstrahantur, nisi clanculum agatur: Atq; ad avulsoris accessum ita contrahantur; ut eas evellere difficile sit, quod idem etiam faciunt quoties flatus tempestatésque urgent. Puto autemillis succum sordidum quem supra diximus carnis loco à natura attributum fuisse : atque meatibus latioribus tanquam intestinis aut interaneis uti. Cæterum pars ea quæ Spongiæ cautibus adhærent eft tanquam folii petiolus, à quo veluti collum quoddam gracile incipit : quod deinde in latitudinem diffusum capitis globum facit. Recentibus nihil est fistulosum, hæsitantque tanquam radicibus. Superne omnes propemodum meatus concreti latent : inferne verò quaterni aut quini patent, per quos

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MICROGRAPHIA.

eas fugere existimamus. From which Description, they seem to be a kind of Plant-Animal that adheres to a Rock, and these small fibres or threads which we have described, seem to have been the Vessels which ('tis very probable) were very much bigger whil'st the Interstitia were fill'd (as he affirms) with a mucous, pulpy or flessly substance; but upon the drying were shrunk into the bigness they now appear.

The texture of it is fuch, that I have not yet met with any other body in the world that has the like, but onely one of a larger fort of Sponge (which is preferv'd in the Museum Harveanum belonging to the most Illustrious and most learned Society of the Phylicians of London) which is of a horney, or rather of a petrify'd fubstance. And of this indeed, the texture and make is exactly the fame with common Sponges, but onely that both the holes and the fibres, or texture of it is exceedingly much bigger, for fome of the holes were above an Inch and half over, and the fibres and texture of it was bigg enough to be diffinguished eafily with ones eye, but confpicuoufly with an ordinary fingle Microfcope. And thefe indeed, seem'd to have been the habitation of some Animal; and examining Aristotle, I find a very confonant account hereunto, namely, that he had known a certain little Animal, call'd Pinnothera, like a Spider, to be bred in those caverns of a Sponge, from within which, by opening and clofing those holes, he infnares and catches the little Fishes; and in another place he fays, That'tis very confidently reported, that there are certain Moths or Worms that refide in the cavities of a Sponge, and are there nourifhed : Notwithstanding all which Histories, I think it well worth the enquiring into the Hiftory and nature of a Sponge, it feeming to promife fome information of the Veffels in Animal fubftances, which (by reafon of the folidity of the interferted flefh that is not eafily remov'd, without destroying also those interspers'd Vessels) are hitherto undiscover'd; whereas here in a Sponge, the Parenchyma, it feems, is but a kind of mucous gelly, which is very eafily and cleerly wash'd away. .

The reason that makes me imagine, that there may probably be some fuch texture in Animal fubstances, is, that examining the texture of the filaments of tann'd Leather, I find it to be much of the fame nature and strength of a Sponge; and with my Microfcope, I have observ'd many fuch joints and knobs, as I have defcribed in Sponges, the fibres also in the hollow of feveral forts of Bones, after the Marrow has been remov'd, I have found fomewhat to refemble this texture, though, I confefs, I never yet found any texture exactly the fame, nor any for curiofity comparable to it. The filaments of it are much smaller then those of Silk, and through the Microscope appear very neer as transparent, nay, some parts of them I have observ'd much more. Having examin'd also several kinds of Mushroms, I finde their texture to be fomewhat of this kind, that is, to confift of an infinite company of fmall filaments, every way contex'd and woven together, fo as to make a kind of cloth, and more particularly, examining a piece of Touch-wood (which is a kind of Jews-ear, or Mushrom, growing here in England alfo, on

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on feveral forts of Trees, fuch as Elders, Maples, Willows, &c. and is commonly call'd by the name of Spunk; but that we meet with to be fold in Shops, is brought from beyond Seas) I found it to be made of an exceeding delicate texture: For the substance of it feels, and looks to the naked eye, and may be ftretch'd any way, exactly like a very fine piece of Chamois Leather, or walh'd Leather, but it is of fomewhat a browner. hew, and nothing neer fo ftrong; but examining it with my Microfcope, I found it of fomewhat another make then any kind of Leather; for whereas both Chamois, and all other kinds of Leather I have yet view'd, confift of an infinite company of filaments, fomewhat like bufhes interwoven one within another, that is, of bigger parts or ftems, as it were, and Imaller branchings that grow out of them; or like a heap of Ropes ends, where each of the larger Ropes by degrees feen to fplit or untwift, into many imaller Cords, and each of those Cords into imaller Lines, and those Lines into Threads, O.c. and these strangely intangled, or interwoven one within another : The texture of this Touch-wood feems more like that of a Lock or a Fleece of Wool, for it confifts of an infinite number of fmall filaments, all of them, as farr as I could perceive, of the lame bigness like those of a Sponge, but that the filaments of this were not a twentieth part of the bigness of those of a Sponge; and I could not to plainly perceive their joints, or their manner of interweaving, though, as farr as I was able to difcern with that Microfcope I had, I suppose it to have fome kind of refemblance, but the joints are nothing neer fo thick, nor without much trouble visible. A diagon on all s gan dialor down out

The filaments I could plainly enough perceive to be even, round, cylindrical, transparent bodies, and to cross each other every way, that is, there were not more seem'd to lie *korizontally* then *perpendicularly* and thwartway, so that it is somewhat difficult to conceive how they should grow in that manner. By tearing off a small piece of it, and looking on the ragged edge, I could among several of those *fibres* perceive small joints, that is, one of those hairs split into two, each of the same bignels with the other out of which they seem'd to grow, but having not lately had an opportunity of examining their manner of growth, I cannot positively affirm any thing of them.

But to proceed, The swelling of Sponges upon wetting, and the rising

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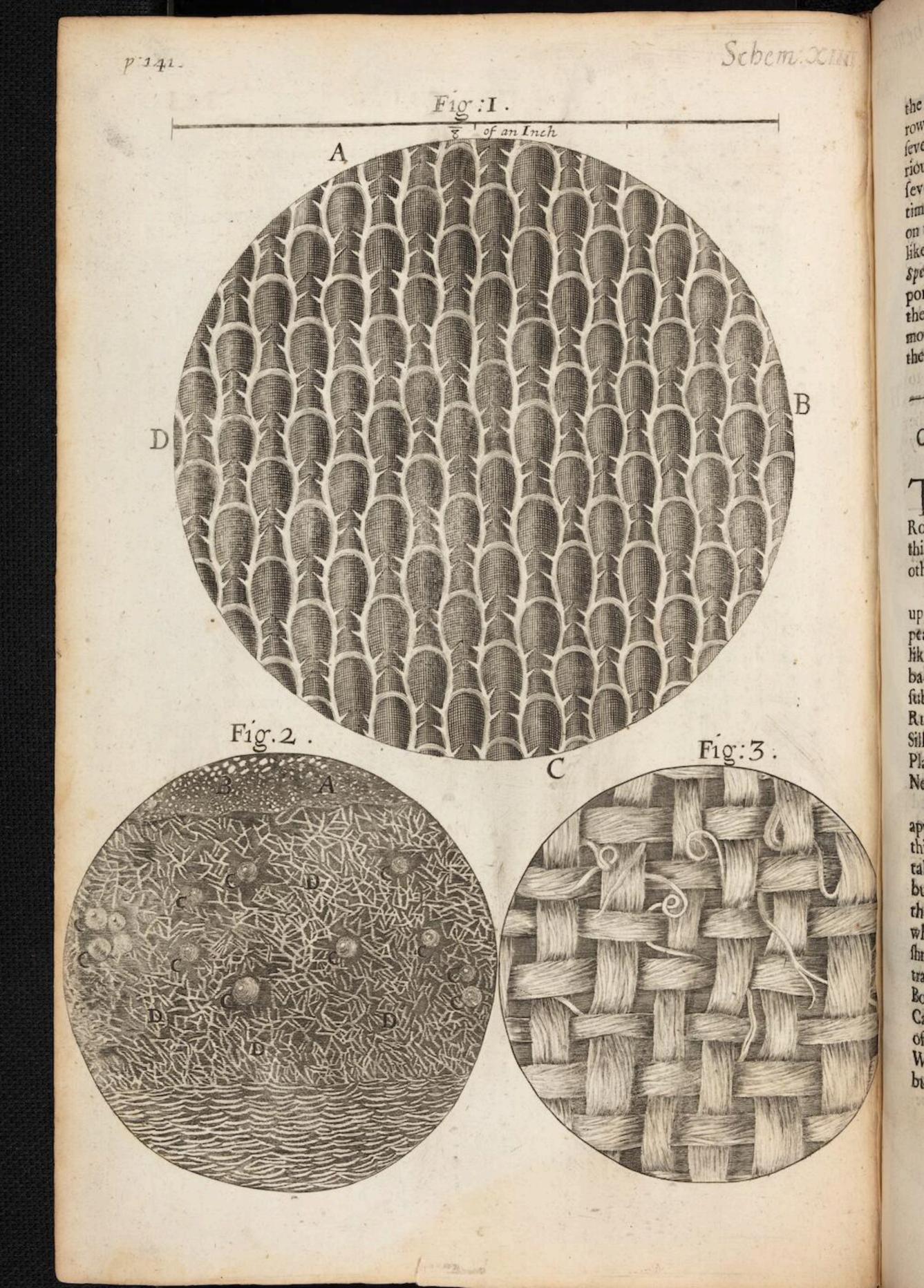
of the Water in it above the furface of the Water that it touches, are both from the fame caufe, of which an account is already given in the fixth Obfervation.

The fubftance of them indeed, has fo many excellent properties, fcarce to be met with in any other body in the world, that I have often wondered that fo little use is made of it, and those onely vile and fordid ; certainly, if it were well confider'd, it would afford much greater conveniencies.

That use which the Divers are faid to make of it, feems, if true, very strange, but having made trial of it my felf, by dipping a small piece of it in very good Sallet-oyl, and putting it in my mouth, and then keeping my mouth and nose under water, I could not find any such thing; for I V 2 Was was as foon out of breath, as if I had had no Sponge, nor could I fetch my breath without taking in water at my mouth; but I am very apt to think, that were there a contrivance whereby the expir'd air might be forc'd to pass through a wet or oyly Sponge before it were again inspir'd, it might much cleanse, and strain away from the Air divers fuliginous and other noisome steams, and the dipping of it in certain liquors might, perhaps, so renew that property in the Air which it loses in the Lungs, by being breath'd, that one square foot of Air might last a man for respiration much longer, perhaps, then ten will now ferve him of common Air.

Observ. XXIII. Of the curious texture of Sea-weeds.

Or curiofity and beauty, I have not among all the Plants or Vege-T tables I have yet observ'd, seen any one comparable to this Sea-weed I have here describ'd, of which I am able to fay very little more then what is represented by the second Figure of the ninth Scheme: Namely, that it is a Plant which grows upon the Rocks under the water, and increases and spreads it self into a great tuft, which is not onely handsomely branch'd into feveral leaves, but the whole furface of the Plant is cover'd over with a most curious kind of carv'd work, which confists of a texture much refembling a Honey-comb; for the whole furface on both fides is cover'd over with a multitude of very fmall holes, being no bigger then fo many holes made with the point of a small Pinn, and rang'd in the neateft and most delicate order imaginable, they being plac'd in the manner of a Quincunx, or very much like the rows of the eyes of a Fly, the rows or orders being very regular, which way foever they are observ'd : what the texture was, as it appear'd through a pretty bigg Magnifying Microscope, I have here adjoin'd in the first Figure of the 14. Scheme. which round Area ABCD represents a part of the surface about one eighth part of an Inch in Diameter : Those little holes, which to the eye look'd round, like fo many little spots, here appear'd very regularly shap'd holes, representing almost the shape of the sole of a round toed fhoe, the hinder part of which, is, as it were, trod on or cover'd by the toe of that next below it; these holes seem'd wall'd about with a very thin and transparent substance, looking of a pale straw-colour; from the edge of which, against the middle of each hole, were sprouted out four small transparent straw-colour'd Thorns, which seem'd to protect and cover those cavities, from either fide two; neer the root of this Plant, were fprouted out feveral small branches of a kind of bastard Coralline, curioufly branch'd, though fmall. And to confirm this, having lately the opportunity of viewing the large Plant (if I may fo call it) of a Sponge petrify'd, of which I made mention in the last Observation, I found, that each of the Branches or Figures of it, did, by the range of its pores, exhibit just fuch a texture, the



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the rows of pores croffing one another, much after the manner as the rows of eyes do which are deferib'd in the 26. Scheme : Coralline alfo, and feveral forts of white Coral, I have with a Microfcope obferv'd very curioufly fhap'd. And I doubt not, but that he that fhall obferve thefe feveral kinds of Plants that grow upon Rocks, which the Sea fometimes overflows, and those heaps of others which are vomited out of it upon the flore, may find multitudes of little Plants, and other bodies, which like this will afford very beautifull objects for the Microfcope ; and this Specimen here is adjoin'd onely to excite their curiofities who have opportunity of obferving to examine and collect what they find worthy, their notice 5 for the Sea, among tetreftrial bodies, is alfo a prolifick mother, and affords as many Infrances of ffontaneous generations as either the Air or Earth.

Observ. XXIV. Of the surfaces of Rosemary, and other leaves.

change their magnitude, that conjecture from d. nor a mained

His which is delineated within the circle of the fecond Figure of the 14. Scheme, is a small part of the back or under fide of a leaf of Rosemary, which I did not therefore make choice of, because it had any thing peculiar which was not observable with a Microscope in several other Plants, but because it exhibits at one view,

First, a smooth and shining surface, namely, A B, which is a part of the upper side of the leaf, that by a kind of hem or doubling of the leaf appears on this fide. There are multitudes of leaves, whose surfaces are like this smooth, and as it were quilted, which look like a curious quilted bagg of green Silk, or like a Bladder, or some such pliable transparent substance, full stuffed out with a green juice or liquor; the surface of Rue, or Herbgrass, is polish'd, and all over indented, or pitted, like the Silk-worm's Egg, which I shall anon describe; the smooth surfaces of other Plants are otherwise quilted, Nature in this, as it were, expressing her Needle-work, or imbroidery.

Next a downy or bufhy furface, fuch as is all the under fide almoft, appearing through the *Microfcope* much like a thicket of bufhes, and with this kind of Down or Hair the leaves and ftalks of multitudes of Vegetables are covered; and there feems to be as great a variety in the fhape, bulk, and manner of the growing of thefe fecundary Plants, as I may call them (they being, as it were, a Plant growing out of a Plant, or fomewhat like the hairs of Animals) as there is to be found amongft fmall fhrubs that compofe bufhes; but for the moft part, they confift of fmall transparent parts, fome of which grow in the fhape of finall Needles or Bodkins, as on the Thiftle, Cowag-ecod and Nettle; others in the form of Cat's claws, as in Cliders, the beards of Barley, the edges of feveral forts of Grafs and Reeds, *Ge.* in other, as Coltsfoot, Rofe-campion, Aps, Poplar, Willow, and almoft all other downy Plants, they grow in the form of bufhes very much diverfify'd in each particular Plant. That which I have before

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before in the 19. Observation noted on Rose-leaves, is of a quite differing kind, and seems indeed a real Vegetable, distinct from the leaf.

Thirdly, among these small bushes are observable an infinite company of small round Balls, exactly Globular, and very much refembling Pearls, namely, CCCC, of these there may be multitudes observ'd in Sage, and feveral other Plants, which I suppose was the reason why Athanasius Kircher fupposed them to be all cover'd with Spiders Eggs, or young Spiders, which indeed is nothing elfe but fome kind of gummous exfudation, which is always much of the fame bignefs. At first fight of these,I confess, I imagin'd that they might have been some kind of matrices, or nourifhing receptacles for fome small Infect, just as I have found Oakapples, and multitudes of fuch other large excrefcencies on the leaves and other parts of Trees and shrubs to be for Flyes, and divers other Infects, but observing them to be there all the year, and scarce at all to change their magnitude, that conjecture feem'd not fo probable. But what ever be the use of it, it affords a very pleasant object through the Microscope, and may, perhaps, upon further examination, prove very luciferous. his delinented within the circle of the fecond Frame of the

Observ. XXV. Of the stinging points and juice of Nettles, and some other venomous Plants.

Nettle is a Plant fo well known to every one, as to what the appear-A ance of it is to the naked eye, that it needs no description; and there are very few that have not felt as well as feen it; and therefore it will be no news to tell that a gentle and flight touch of the fkin by a Nettle, does oftentime, not onely create very fenfible and acute pain, much like that of a burn or fcald, but often also very angry and hard fwellings and inflamations of the parts, fuch as will prefently rife, and continue fwoln divers hours. These observations, I fay, are common enough; but how the pain is fo fuddenly created, and by what means continued, augmented for a time, and afterwards diminish'd, and at length quite exstinguish'd, has not, that I know, been explain'd by any. And here we must have recourse to our Microscope, and that will, if almost any part of the Plant be looked on, shew us the whole surface of it very thick fet with turn-Pikes, or fharp Needles, of the fhape of those represented in the 15. Scheme and first Figure by A B, which are visible alfo to the naked eye; each of which confifts of two parts very diffinct for fhape, and differing also in quality from one another. For the part A, is fhaped very much like a round Bodkin, from B tapering till it end in a very fharp point; it is of a fubftance very hard and stiff, exceedingly transparent and cleer, and, as I by many trials certainly found, is hollow from top to bottom. SITIOL SIL OTHER COVERY FIAME

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This I found by this Experiment, I had a very convenient Microfcope



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fcope with a fingle Glafs which drew about half an Inch, this I had faftned into a little frame, almost like a pair of Spectacles, which I placed before mine eyes, and fo holding the leaf of a Nettle at a convenient diffance from my eye, I did first, with the thrusting of several of these bristles into my fkin, perceive that prefently after I had thruft them in I felt the burning pain begin; next I observed in divers of them, that upon thrusting my finger against their tops, the Bodkin (if I may fo call it) did not in the leaft bend, but I could perceive moving up and down within it a certain liquor, which upon thrufting the Bodkin against its basis, or bagg B, I could perceive to rife towards the top, and upon taking away my hand, I could fee it again fubfide, and fhrink into the bagg; this I did very often, and faw this Phænomenon as plain as I could ever fee a parcel of water afcend and defcend ina pipe of Glafs. But the bafis underneath thefe Bodkins on which they were fast, were made of a more pliable fubstance, and looked almost like a little bagg of green Leather, or rather refembled the shape and surface of a wilde Cucumber, or cucumeris afinini, and I could plainly perceive them to be certain little baggs, bladders, or receptacles full of water, or as I ghels, the liquor of the Plant, which was poifonous, and those small Bodkins were but the Syringe-pipes, or Glyfter-pipes, which first made way into the skin, and then ferved to convey that poilonous juice, upon the prefling of those little baggs, into the interior and sensible parts of the skin, which being so discharg'd, does corrode, or, as it were, burn that part of the fkin it touches; and this pain will fometimes laft very long, according as the imprefiion is made deeper or ftronger.

The other parts of the leaf or furface of the Nettle, have very little confiderable, but what is common to molt of these kinds of Plants, as the ruggedness or indenting, and hairiness, and other roughnesses of the furface or out-fide of the Plant, of which I may fay more in another place. As I shall likewife of certain little pretty cleer Balls or Apples which I have observed to stick to the fides of these leaves, both on the upper and under fide, very much like the small Apples which I have often observ'd to grow on the leaves of an Oak call'd Oak-apples which are nothing but the Matrices of an Infect, as I elfewhere shew.

The chief thing therefore is, how this Plant comes, by fo flight a touch, to create fo great a pain; and the reason of this seems to be nothing elfe, but the corrofive penetrant liquor contain'd in the small baggs or bladders, upon which grow out those sharp Syringe-pipes, as I before noted; and very confonant to this, is the reason of the pain created by the sting of a Bee, Walp, O.c. as I elsewhere shew: For by the Dart, which is likewife a pipe, is made a deep passage into the skin, and then by the anger of the Fly, is his gally poifonous liquor injected ; which being admitted among the fenfible parts, and fo mix'd with the humours or ftagnating juices of that part, does create an Ebullition perhaps, or effervescens, as is usually observ'd in the mingling of two differing Chymical faline liquors, by which means the parts become fwell'd, hard, and very painfull; for thereby the nervous and sensible parts are not onely stretch'd and strain'd beyond

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beyond their natural tone, but are also prick'd, perhaps, or corroded by the pungent and incongruous pores of the intruded liquor.

And this feems to be the reafon, why Aqua fortis, and other faline liquors, if they come to touch the fenfitive parts, as in a cut of the fkin, or the like, do fo violently and intollerably excruciate and torment the Patient. And 'tis not unlikely, but the Inventors of that Diabolical practice of poifoning the points of Arrows and Ponyards, might receive their firft hint from fome fuch Inftance in natural contrivances, as this of the Nettle : for the ground why fuch poifon'd weapons kill fo infallibly as they do, feems no other then this of our Nettle's ftinging; for the Ponyard or Dart makes a paffage or entrance into the fenfitive or vital parts of the body, whereby the contagious fubftance comes to be diffolv'd by, and mix'd with the fluid parts or humours of the body, and by that means fpreads it felf by degrees into the whole liquid part of the body, in the fame manner, as a few grains of Salt, put into a great quantity of Water, will by degrees diffufe it felf over the whole.

And this I take to be the reason of killing of Toads, Frogs, Effs, and feveral Fishes, by strewing Salt on their backs (which Experiment was shewn to the *Royal Society* by a very ingenious Gentleman, and a worthy Member of it) for those creatures having always a continual exfudation, as it were, of slimy and watry parts, sweating out of the pores of their skin, the *faline* particles, by that means obtain a *vehicle*, which conveys them into the internal and vital parts of the body.

This feems also to be the reason why bathing in Mineral waters are fuch foveraign remedies for multitudes of diftempers, especially chronical; for the liquid & warm vehicles of the Mineral particles, which are known to be in very confiderable quantities in those healing baths, by the body's long stay in them, do by degrees steep and infinuate themselves into the pores and parts of the skin, and thereby those Mineral particles have their ways and passages open'd to penetrate into the inner parts, and mingle themfelves with the ftagnant juices of the feveral parts ; befides, many of those offensive parts which were united with those ftagnant juices, and which were contrary to the natural conftitution of the parts, and fo become irkfome and painfull to the body, but could not be discharged, becaufe Nature had made no provision for fuch accidental mischiefs, are, by means of this foaking, and filling the pores of the skin with a liquor, afforded a passage through that liquor that fills the pores into the ambient fluid, and thereby the body comes to be discharged. So that 'tis very evident, there may be a good as well as an evil application of this Principle. And the ingenious Invention of that Excellent perfon, Doctor Wren, of injecting liquors into the veins of an Animal, feems to be reducible to this head : I cannot stay, nor is this a fit place, to mention the feveral Experiments made of this kind by the most incomparable Mr. Boyle, the multitudes made by the lately mention'd Phylician Doctor Clark, the Hiftory whereof, as he has been pleas'd to communicate to the Royal Society, fo he may perhaps be prevail'd with to make publique himfelf: But I shall rather hint, that certainly, if this Principle were

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were well confider'd, there might, befides the further improving of Bathing and Syringing into the veins, be thought on feveral ways, whereby feveral obstinate distempers of a humane body, such as the Gout, Dropsie, Stone, *O.e.* might be master'd, and expell'd; and good men might make as good a use of it, as evil men have made a perverse and Diabolical.

And that the filling of the pores of the fkin with fome fluid vehicle, is of no fmall efficacy towards the preparing a paffage for feveral kinds of penetrant juices, and other difioluble bodies, to infinuate themfelves within the ikin, and into the feufitive parts of the body, may be, I think, prov'd by an Instance given us by Bellonius, in the 26. Chapter of the fecond Book of his Observations, which containing a very remarkable Story I have here transcrib'd: Cum Chameleonis nigri radices (fays he) apud Pagum quendam Livadochorio nuncupatum erui curaremus, plurimi Graci & Turca fectatum venerunt quid erueremus, eas vero frustulatim fecabamus, & filo trajiciebamus ut facilius exficcari possent. Turce in eo negotio occupatos nos videntes, similiter cas radices tractare & secare voluerunt: at cum summus esset estus, & omnes sudore maderent, quicunque eam radicem manibus tractaverant sudoremque absterserant, aut faciem digitis scalpserant, tantam pruriginem iis locis quos attigerant postea senserunt, ut aduri viderentur. Chamalconis enim nigri radix ea virtute pollet. ut cuti applicata ipsam adeo inflammet, ut nec squilla, nec urtica ulla centesima parte it a adurent : At prurigo non adeo celeriter seje prodit. Post unam aut alteram porro boram, linguli variis faciei locis cutem adeo inflammatam habere capimus ut tota sanguinea videretur, atque quo magis eam confricabamus tanto magis excitabatur prurigo. Fonti affidebamus sub platano, atque initio pro ludicro habebamus & ridebamus : at tandem illi plurimum indignati funt, O nifi afjeveraffemus nunquam expertos tali virtute eam plantam pollere, hand dubie male nos multassent. Attamen nostra excusatio fuit ab illis facilius accepta, cum eodem incommodo nos affectos conspicerent. Mirum sane quod in tantillo radice tam ingentem efficaciam nostro malo experti sumus.

By which obfervation of his, it feems manifeft, that their being all cover'd with fweat who gather'd and cut this root of the black *Chameleon* Thiftle, was the great reafon why they fuffer'd that inconvenience, for it feems the like circumftance had not been before that noted, nor do I find any mention of fuch a property belonging to this Vegetable in any of the Herbals I have at prefent by me. I could give very many Obfervations which I have made of this kind, whereby I have found that the beft way to get a body to be infinuated into the fubftance or infenfible pores of another, is first, to find a fluid vehicle that has fome congruity, both to the body to be infinuated, and to the body into whofe pores you would have the other convey'd. And in this Principle lies the great mystery of staining feveral forts of bodies, as Marble, Woods, Bones, & c. and of Dying Silks, Cloaths, Wools, Feathers, & c. But thefe being digreffions, I shall proceed to:

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Observ. X X V I. Of Cowage, and the itching operation of some bodies. There is a certain Down of a Plant, brought from the East-Indies, call'd commonly, though very improperly, Cow-itch, the reason of which X mistake

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mistake is manifest enough from the description of it, which Mr. Parkinson fets down in his Herbal, Tribe XI. Chap. 2. Phassochastic filiqua hirsuta; The hairy Kidney-bean, called in Zurratte where it grows, Couhage: We have had (fayshe) another of this kind brought us out of the East-Indies, which being planted, was in shew like the former, but came not to perfection, the unkindly season not suffering it to shew the flower; but of the Cods that were brought, fome were smaller, shorter, and rounder then the Garden kind; others much longer, and many growing together, as it were in clusters, and cover d all over with a brown short hairines, so fine, that if any of it be rubb'd, or fall on the back of ones hand, or other tender parts of the skin, it will cause a kind of itching, but not strong, nor long induring, but palsing quickly away, without either danger or harm; the Beans were smaller then ordinary, and of a black shining colour.

Having one of these Cods given me by a Sea-Captain, who had frequented those parts, I found it to be a small Cod, about three Inches long, much like a fhort Cod of French Beans, which had fix Beans in it, the whole furface of it was cover'd over with a very thick and fhining brown Down or Hair, which was very fine, and for its bignefs ftiff; taking fome of this Down, and rubbing it on the back of my hand, 1 found very little or no trouble, only I was fensible that feveral of these little downy parts with rubbing did penetrate, and were funk, or ftuck pretty deep into my fkin. After I had thus rubb'd it for a pretty while, I felt very little or no pain, in fo much that I doubted, whether it were the true Couhage; but whil'ft I was confidering, I found the Down begin to make my hand itch, and in fome places to fmart again, much like the ftinging of a Flea or Gnat, and this continued a pretty while, fo that by degrees I found my fkin to be fwell'd with little red puffules, and to look as if it had been itchie. But fuffering it without rubbing or fcratching, the itching tickling pain quickly grew languid, and within an hour I felt nothing at all, and the little protuberancies were vanish'd.

The caufe of which odd Phanomenon, I suppose to be much the fame with that of the ftinging of a Nettle, for by the Microscope, I discover'd this Down to confift of a multitude of small and slender conical bodies, much refembling Needles or Bodkins, fuch as are reprefented by A B. C D. EF. of the first Figure of the XVI. Scheme; that their ends A A A, were very fharp, and the fubstance of them stiff and hard, much like the fubstance of several kinds of Thorns and crooks growing on Trees. And though they appear'd very cleer and transparent, yet I could not perceive whether they were hollow or not, but to me they appear'd like folid transparent bodies, without any cavity in them; whether, though they might not be a kind of Cane, fill'd with fome transparent liquor which was hardned (because the Cod which I had was very dry) I was not able to examine. Now, being fuch stiff, sharp bodies, it is easie to conceive, how with rubbing they might eafily be thrust into the tender parts of the skin, and there, by reason of their exceeding fineness and driness, not create any confiderable trouble or pain, till by remaining in those places moistned with the humours of the body, some caustick part sticking on them, or refiding

refiding w of that P come affe on lafts, t which is t That t Wafp, an in their F Horf-hai feems to

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refiding within them might be diffolv'd and mix'd with the ambient juices of that place, and thereby those *fibres* and tender parts adjoyning become affected, and as it were corroded by it; whence, while that action last, the pains created are pretty sharp and pungent, though small, which is the effential property of an itching one.

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That the pain also caused by the stinging of a Flea, a Gnat, a Flie, a Wasp, and the like, proceeds much from the very same cause, I elsewhere in their proper places endeavour to manifest. The stinging also of shred Horf-hair, which in meriment is often strew'd between the stress of a Bed, seems to proceed from the same cause.

Observ. XXVII. Of the Beard of a wilde Oat, and the use that may be made of it for exhibiting always to the Eye the temperature of the Air, as to driness and moissure.

T His Beard of a wild Oat, is a body of a very curious ftructure, though to the naked Eye it appears very flight, and inconfiderable, it being only a fmall black or brown Beard or Briftle, which grows out of the fide of the inner Husk that covers the Grain of a wild Oat; the whole length of it, when put in Water, fo that it may extend it felf to its full length, is not above an Inch and a half, and for the most part fomewhat florter, but when the Grain is ripe, and very dry, which is usually in the Moneths of July, and August, this Beard is bent fomewhat below the middle, namely, about from the bottom of it, almost to a right Angle, and the under part of it is wreath'd lik a With; the substance of it is very brittle when dry, and it will very eafily be broken from the husk on which it grows.

If you take one of these Grains, and wet the Beard in Water, you will prefently see the small bended top to turn and move round, as if it were sensible; and by degrees, if it be continued wet enough, the joint or knee will streighten it felf; and if it be suffer'd to dry again, it will by degrees move round another way, and at length bend again into its former

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If it be view'd with an ordinary fingle *Microfcope*, it will appear like a fmall wreath'd Sprig, with two clefts; and if wet as before, and then look'd on with this *Microfcope*, it will appear to unwreath it felf, and by degrees, to streighten its knee, and the two clefts will become streight, and almost on opposite fides of the small cylindrical body.

If it be continued to be look'd a little longer with a *Microfcope*, it will within a little while begin to wreath it felf again, and foon after return to its former pofture, bending it felf again neer the middle, into a kind of knee or angle.

Several of those bodies I examin'd with larger Microscopes, and there found them much of the make of those two long wreath'd cylinders delineated in the second Figure of the 15. Scheme, which two cylinders re-X 2 present

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prefent the wreathed part broken into two pieces, whereof the end A B is to be fuppos'd to have join'd to the end CD, fo that EA CF does reprefent the whole wreath'd part of the Beard, and E G a fmall piece of the upper part of the Beard which is beyond the knee, which as I had not room to infert, fo was it not very confiderable, either for its form, or any known property; but the under or wreathed part is notable for both: As to its form, it appear'd, if it were look'd on fide-ways, almost like a Willow, or a fmall tapering rod of *Hazel*, the lower or bigger half of which onely, is twifted round feveral times, in fome three, in others more, in others lefs, according to the bignefs and maturity of the Grain on which it grew, and according to the drinefs and moifture of the ambient Air, as I shall flew more at large by and by.

The whole outward Superficies of this Cylindrical body is curioufly adorned or fluted with little channels, and interjacent ridges, or little protuberances between them, which run the whole length of the Beard, and are ftreight where the Beard is not twifted, and wreath'd where it is, just after the fame manner: each of those fides is befet pretty thick with fmall Brifles or Thorns, fomewhat in form refembling that of *Porcupines* Quills, fuch as *a a a a a* in the Figure ; all whose points are directed like fo many Turn-pikes towards the fmall end or top of the Beard, which is the reason, why, if you endeavour to draw the Beard between your fingers the contrary way, you will find it to stick, and grate, as it were, against the fkin.

The proportion of these small conical bodies *a a a a a* to that whereon they grow, the Figure will sufficiently shew, as also their manner of growing, their thickness, and neerness to each other, as, that towards the root or bottom of the Beard, they are more thin, and much shorter, infomuch that there is usually left between the top of the one, and the bottom of that next above it, more then the length of one of them, and that towards the top of the Beard they grow more thick and close (though there be fewer ridges) so that the root, and almost half the upper are hid by the tops of those next below them.

I could not perceive any transverse pores, unless the whole wreath'd part were separated and cleft, in those little channels, by the wreathing into fo many little ftrings as there were ridges, which was very difficult to determine; but there were in the wreathed part two very confpicuous channels or clefts, which were continued from the bottom F to the elbow E H, or all along the part which was wreath'd, which feem'd to divide the wreath'd Cylinder into two parts, a bigger and a lefs; the bigger was that which was at the convex fide of the knee, namely, on the fide A, and was wreath'd by 00000; this, as it feem'd the broader, fo did it also the longer, the other PPPPP, which was usually purs'd or wrinckled in the bending of the knee, as about E, feem'd both the fhorter and narrower, fo that at first I thought the wreathing and unwreathing of the Beard might have been caus'd by the fhrinking or fwelling of that part; but upon further examination, I found that the clefts, K K, L L, were Ituit up with a kind of Spongie fubstance, which, for the most part, was very

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very confpicuous neer the knee, as in the cleft K K, when the Beard was dry; upon the difcovery of which, I began to think, that it was upon the fwelling of this porous pith upon the accefs of moifture or water that the Beard, being made longer in the midft, was ftreightned, and by the flirinking or fubfiding of the parts of that Spongie fubftance together, when the water or moifture was exhal'd or dried, the pith or middle parts growing florter, the whole became twifted.

But this I cannot be politive in, for upon cutting the wreath'd part in many places transversly, I was not fo well fatisfy'd with the shape and manner of the pores of the pith; for looking on these transverse Sections with a very good *Microscope*, I found that the ends of those transverse Sections appear'd much of the manner of the third Figure of the' 15. Scheme ABCFE, and the middle or pith CC, seem'd very full of pores indeed, but all of them seem'd to run the long-ways.

This Figure plainly enough fhews in what manner those clefts, K and L divided the wreath'd Cylinder into two unequal parts, and also of what kind of substance the whole body confists; for by cutting the same Beard in many places, with transverse Sections, I found much the same appearance with this express'd; so that those pores seem to run, as in most other such Cany bodies, the whole length of it.

The clefts of this body KK, and LL, feem'd (as is also express'd in the Figure) to wind very oddly in the inner part of the wreath; and in some parts of them, they seem'd stuffed, as it were, with that Spongie substance, which I just now described.

This fo oddly conftituted Vegetable fubftance, is first (that I have met with) taken notice of by *Baptista Porta*, in his *Natural Magick*, as a thing known to children and Juglers, and it has been call'd by fome of those last named perfons, the better to cover their cheat, the Legg of an *Arabian Spider*, or the Legg of an inchanted *Egyptian Fly*, and has been used by them to make a small Index, Cross, or the like, to move round upon the wetting of it with a drop of Water, and muttering certain words.

But the use that has been made of it, for the discovery of the various constitutions of the Air, as to driness and moistness, is incomparably beyond any other; for this it does to admiration: The manner of contriving it fo, as to perform this great effect, is onely thus:

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Provide a good large Box of Ivory, about four Inches over, and of what depth you fhall judge convenient (according to your intention of making use of one, two,three,or more of these fmall Beards,ordered in the manner which I shall by and by describe) let all the fides of this Box be turned of Basket-work (which here in *London* is easily enough procur'd) full of holes, in the manner almost of a Lettice, the bigger, or more the holes are, the better, that fo the Air may have the more free passage to the inclosed Beard, and may the more easily pass through the Instrument; it will be better yet, though not altogether to handsom, if insteed of the Basketwork on the fides of the Box, the bottom and top of the Box be join'd together onely with three or four small Pillars, after the manner reprefented

fented in the 4.Figure of the 15. Scheme. Or, if you intend to make use of many of these small Beards join'd together, you may have a small long Case of Ivory, whose sides are turn'd of Basket-work, full of holes, which may be served on to the underside of a broad Plate of Ivory, on the other fide of which is to be made the divided Ring or Circle, to which divisions the pointing of the Hand or Index, which is moved by the conjoin'd Beard, may shew all the *Minute* variations of the Air.

There may be multitudes of other ways for contriving this fmall Inftrument, fo as to produce this effect, which any one may, according to his peculiar ufe, and the exigency of his prefent occasion, eafily enough contrive and take, on which I shall not therefore infist. The whole manner of making any one of them is thus: Having your Box or frame A A B B, fitly adapted for the free passage of the Air through it, in the midft of the bottom B B B, you multhave a very small hole C, into which the lower end of the Beard is to be fixd, the upper end of which Beard a b, is to pass through a small hole of a Plate, or top A A, if you make use onely of a single one, and on the top of it e, is to be fix'd a small and very light *Index f g*, made of a very thin fliver of a Reed or Cane ; but if you make use of two or more Beards, they must be fix'd and bound together, either with a very fine piece of Silk, or with a very small touch of hard Wax, or Glew, which is better, and the *Index f g*, is to be fix'd on the top of the fecond, third, or fourth in the same manner as on the fingle one.

Now, because that in every of these contrivances, the Index fg, will with some temperatures of Air, move two, three, or more times round, which without fome other contrivance then this, will be difficult to diffinguish, therefore I thought of this Expedient : The Index or Hand fg, being rais'd a pretty way above the furface of the Plate AA, fix in at a little distance from the middle of it a small Pin b, so as almost to touch the furface of the Plate A A, and then in any convenient place of the furface of the Plate, fix a fmall Pin, on which put on a fmall piece of Paper, or thin Past-board, Vellom, or Parchment, made of a convenient cize, and shap'd in the manner of that in the Figure express'd by ik, fo that having a convenient number of teeth every turn or return of the Pin b, may move this small indented Circle, a tooth forward or backwards, by which means the teeth of the Circle, being mark'd, it will be thereby very easie to know certainly, how much variation any change of weather will make upon the small wreath'd body. In the making of this Secundary Circle of Vellom, or the like, great care is to be had, that it be made exceeding light, and to move very eafily, for otherwife a fmall variation will spoil the whole operation. The Box may be made of Brass, Silver, Iron, or any other fubstance, if care be taken to make it open enough, to let the Air have a fufficiently free access to the Beard. The Index also may be various ways contrived, fo as to shew both the number of the revolutions it makes, and the Minute divisions of each revolution. I have made feveral trials and Inftruments for discovering the driness and moisture of the Air with this little wreath'd body, and find it to vary exceeding fenfibly with the least change in the constitution of the Air, as to

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to drinefs and moifture, fo that with one breathing upon it, I have made it untwift a whole bout, and the *Index* or *Hand* has fhew'd or pointed to various divifions on the upper Face or Ring of the Inftrument, according as it was carried neerer and neerer to the fire, or as the heat of the Sun increafed upon it.

Other trials I have made with Gut-ftrings, but find them nothing neer fo fenfible, though they alfo may be fo contriv'd as to exhibit the changes of the Air, as to drinefs and molfture, both by their ftretching and fbrinking in length, and alfo by their wreathing and unwreathing themfelves; but thefe are nothing neer fo exact or fo tender; for their varying property will in a little time change very much. But there are feveral other Vegetable fubftances that are much more fenfible then even this Beard of a wilde Oat; fuch I have found the Beard of the feed of Mufk-grafs, or Geranium mofchatum, and those of other kinds of Cranesbil feeds, and the like. But always the fmaller the wreathing fubftance be, the more fenfible is it of the mutations of the Air, a conjecture at the reason of which I shall by and by add.

The lower end of this wreath'd Cylinder being fluck upright in a little foft Wax, fo that the bended part or *Index* of it lay *horizontal*, I have obferv'd it always with moifture to unwreath it felf from the Eaft (For inftance) by the South to the Weft, and fo by the North to the Eaft again, moving with the Sun (as we commonly fay) and with heat and drouth to re-twift, and wreath it felf the contrary way, namely, from the Eaft, (for inftance) by the North to the Weft, and fo onwards.

The cause of all which Phanomena, seems to be the differing texture of the parts of these bodies, each of them (especially the Beard of a wilde Oat, and of Mosk-grafs feed) feening to have two kind of substances, one that is very porous loofe, and spongie, into which the watry steams of the Air may be very eafily forced, which will be thereby fwell'd and extended in its dimensions, just as we may observe all kind of Vegetable subfrance upon freeping in water to fwell and grow bigger and longer. And a fecond that is more hard and clofe, into which the water can very little, or not at all penetrate, this therefore retaining always very neer the fame dimenfions, and the other ftretching and fhrinking, according as there is more or lefs moilture or water in its pores, by reafon of the make and shape of the parts, the whole body must necessarily unwreath and wreath it felf. And upon this Principle, it is very easie to make several forts of contrivances that fhould thus wreath and unwreath themfelves, either by heat and cold, or by drinefs and moifture, or by any greater or lefs force, from whatever caufe it proceed, whether from gravity or weight, or from wind which is motion of the Air, or from fome fpringing body, or the like. have onerv deferibed tour forrs

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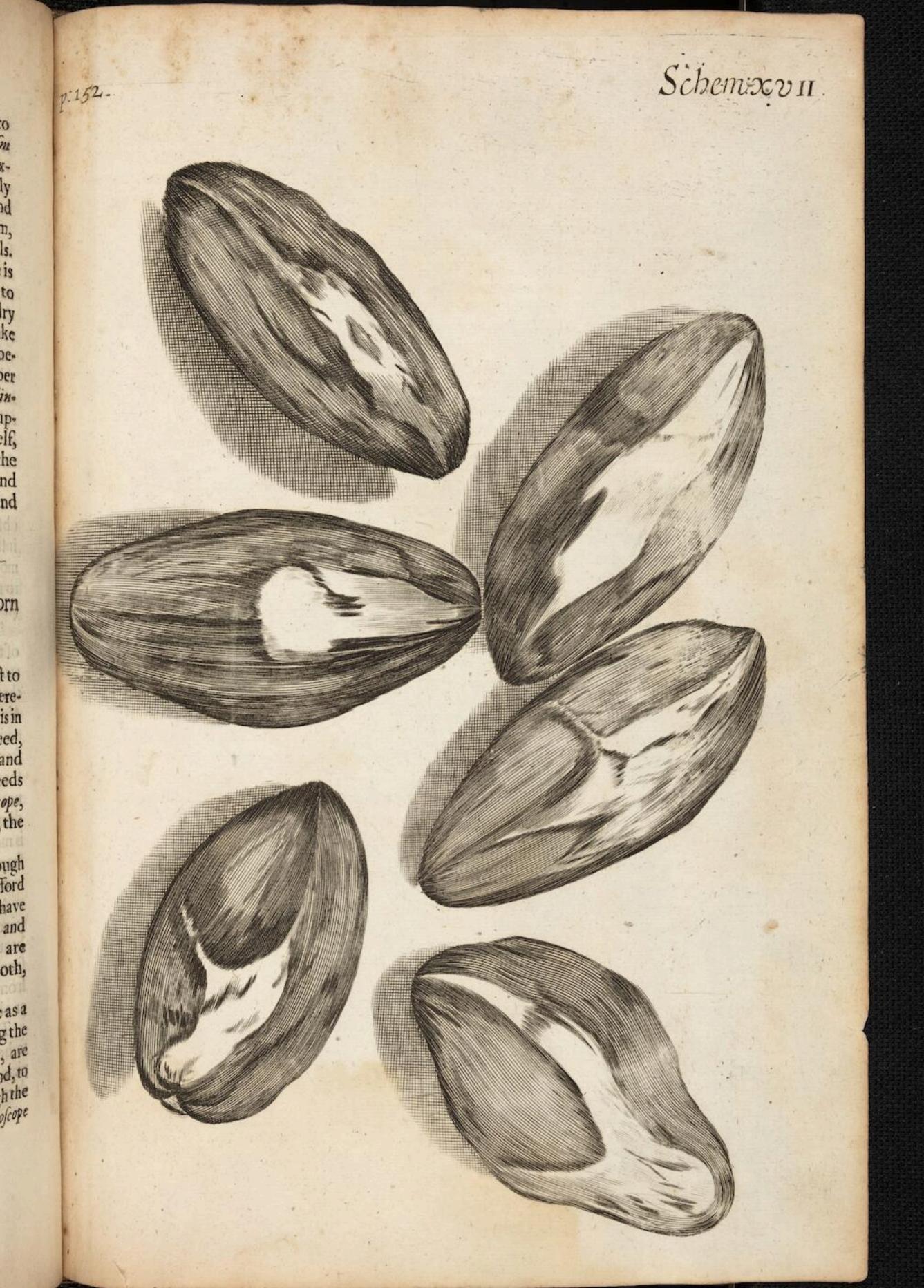
This, had I time, I fhould enlarge much more upon; for it feems to me to be the very first footstep of *Sensation*, and Animate motion, the most plain, simple, and obvious contrivance that Nature has made use of to produce a motion, next to that of Rarefaction and Condensation by heat and

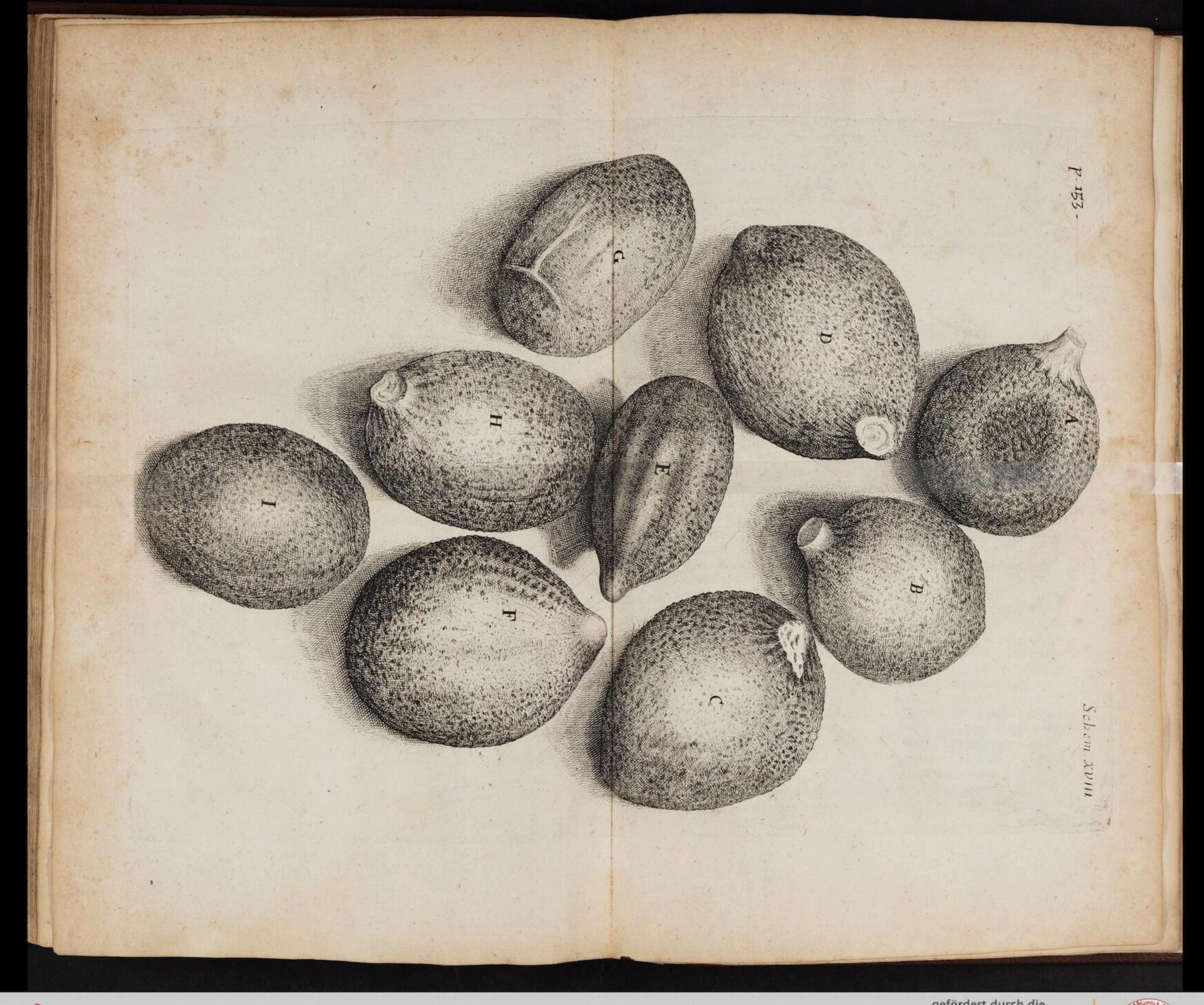
and cold. And were this Principle very well examin'd, I am very apt to think, it would afford us a very great help to find out the *Mechanifm* of the Mufcles, which indeed, as farr as I have hitherto been able to examine, feems to me not fo very perplex as one might imagine, efpecially upon the examination which I made of the Mufcles of *Crabs*, *Lobfters*, and feveral forts of large Shell-fifh, and comparing my Obfervations on them, with the circumftances I obferv'd in the mufcles of terreftrial Animals.

Now, as in this Inftance of the Beard of a wilde Oat, we fee there is nothing elfe requifite to make it wreath and unwreath it felf, and to ftreighten and bend its knee, then onely a little breath of moift or dry Air, or a fmall atome almost of water or liquor, and a little heat to make it again evaporate; for, by holding this Beard, plac'd and fix'd as I before directed, neer a Fire, and dipping the tip of a fmall fhred of Paper in well rectify'd spirit of Wine, and then touching the wreath'd Cylindrical part, you may perceive it to untwist it felf; and prefently again, upon the avolation of the spirit, by the great heat, it will re-twist it felf, and thus will it move forward and backwards as oft as you repeat the touching it with the spirit of Wine; so may, perhaps, the fhrinking and relaxing of the muscles be by the influx and evaporation of some kind of liquor or juice. But of this Enquiry I shall add more elsewhere.

Observ. XXVIII. Of the Seeds of Venus looking-glaß, or Corn Violet.

CRom the Leaves, and Downs, and Beards of Plants, we come at last to T the Seeds ; and here indeed feems to be the Cabinet of Nature, wherein are laid up its Jewels. The providence of Nature about Vegetables, is in no part manifested more, then in the various contrivances about the feed, nor indeed is there in any part of the Vegetable fo curious carvings, and beautifull adornments, as about the feed ; this in the larger forts of feeds is most evident to the eye; nor is it less manifest through the Microscope, in those feeds whose shape and structure, by reason of their smalness, the eye is hardly able to diffinguish. Of these there are multitudes, many of which I have observ'd through a Microscope, and find, that they do, for the most part, every one afford exceeding pleafant and beautifull objects. For befides those that have various kinds of carv'd furfaces, there are other that have fmooth and perfectly polish'd furfaces, others a downy hairy furface; fome are eover'd onely with a fkin, others with a kind of fhell, others with both, toan wind which is motion of a as is observable also in greater feeds. Of these feeds I have onely described four forts which may ferve as a specimen of what the inquifitive observers are likely to find among the reft. The first of these seeds which are described in the 17. Scheme, are those of Corn-Violets, the feed is very small, black, and shining, and, to the naked eye, looks almost like a very small Flea; But through the Microscope





Mic roscope, it appears a large body, cover'd with a tough thick and bright reflecting fkin very irregularly fhrunk and pitted, infomuch that it is almost an impoffibility to find two of them wrinkled alike, fo great a variety may there be even in this little feed.

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This, though it appear'd one of the most promising feeds for beauty to the naked eye, yet through the *Microscope* it appear'd but a rude mission feed, which I therefore drew, that I might thereby manifest how unable we are by the naked eye to judge of beauteous or less curious *microscopical* Objects; cutting some of them in funder, I observ'd them to be fill'd with a greenish yellow pulp, and to have a very thick husk, in proportion to the pulp.

Observ. XXIX. Of the Seeds of Tyme.

vize, and practifies as every, the ri-

Hefe pretty fruits here reprefented, in the 18. Scheme, are nothing elfe, but nine feveral feeds of Tyme; they are all of them in differing pofture, both as to the eye and the light; nor are they all of them exactly of the fame fhape, there being a great variety both in the bulk and figure of each feed; but they all agreed in this, that being look'd on with a Microfcope, they each of them exactly refembled a Lemmon or Orange dry'd; and this both in fhape and colour. Some of them are a little rounder, of the fhape of an Orange, as A and B, they have each of them a very confpicuous part by which they were join'd to their little ftalk, and one of them had a little piece of ftalk remaining on 3 the oppofite fide of the feed, you may perceive very plainly by the Figure, is very copped and prominent, as is very ufual in Lemmons, which prominencies are exprefs'd in D, E and F.

They feem'd each of them a little creas'd or wrinckled, but E was very confpicuoully furrow'd, as if the inward make of this feed had been fomewhat like that of a Lemmon alfo, but upon dividing feveral feeds with a very sharp Pen-knife, and examining them afterward, I found their make to be in nothing but bulk differing from that of Peas, that is, to have a pretty thick coat, and all the reft an indifferent white pulp, which feem'd very close; fo that it feems Nature does not very much alter her method in the manner of inclosing and preferving the vital Principle in the feed, in these very small grains, from that of Beans, Peas, &c. The Grain affords a very pretty Object for the Microscope, namely, a Difh of Lemmons plac'd in a very little room; fhould a Lemmon or Nut be proportionably magnify'd to what this feed of Tyme is, it would make it appear as bigg as a large Hay-reek, and it would be no great wonder to fee Homers Iliads, and Homer and all, cramm'd into fuch a Nut-fhell. We may perceive even in these small Grains, as well as in greater, how curious and carefull Nature is in preferving the feminal principle of Vegetable bodies, in what delicate, strong and most convenient Cabinets she lays

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it.

lays them and closes them in a pulp for their fafer protection from outward dangers, and for the fupply of convenient alimental juice, when the heat of the Sun begins to animate and move these little antomatons or Engines; as if she would, from the ornaments wherewith she has deckt these Cabinets, hint to us, that in them she has Taid up her Jewels and Master-pieces. And this, if we are but diligent in observing, we shall find her method throughout. There is no curiofity in the Elemental kingdom, if I may fo call the bodies of Air, Water, Earth, that are comparable in form to those of Minerals; Air and Water having no form at all, unless a potentiality to be form'd into Globules; and the clods and parcels of Earth are all irregular, whereas in Minerals she does begin to Geometrize, and practife, as 'twere, the first principles of Mechanicks, fhaping them of plain regular figures, as triangles, squares, &c. and tetraedrons, cubes, O.c. But none of their forms are comparable to the more compounded ones of Vegetables; For here she goes a step further, forming them both of more complicated shapes, and adding also multitudes of curious Mechanick contrivances in their ftructure; for whereas in Vegetables there was no determinate number of the leaves or branches, nor no exactly certain figure of leaves, or flowers, or feeds, in Animals all those things are exactly defin'd and determin'd; and where-ever there is either an excels or defect of those determinate parts or limbs, there has been fome impediment that has fpoil'd the principle which was most regular : Here we shall find, not onely most curiously compounded shapes, but most stupendious Mechanisms and contrivances, here the ornaments are in the highest perfection, nothing in all the Vegetable kingdom that is comparable to the deckings of a Peacock; nay, to the curiofity of any feather, as I elsewhere shew; nor to that of the smallest and most despicable Fly. But I must not stay on these speculations, though perhaps it were very well worth while for one that had leifure, to fee what Information may be learn'd of the nature, or use, or virtues of bodies, by their feveral forms and various excellencies and properties. Who knows but Adam might from fome fuch contemplation, give names to all creatures? If at leaft his names had any fignificancy in them of the creature's nature on which he impos'd it; as many (upon what grounds I know not) have Suppos'd : And who knows, but the Creator may, in those characters, have written and engraven many of his most mysterious designs and counsels, and given man a capacity, which, affifted with diligence and induftry, may be able to read and understand them. But not to multiply my digreffion more then I can the time, I will proceed to the next, which is,

Observ. XXX. Of the Seeds of Poppy.

moons plac'd in a very little noon allouid al emmon or iver

The finall feeds of Poppy, which are defcribed in the 19. Scheme, both for their finalnefs, multiplicity and prettinefs, as alfo for their admirable foporifick quality, deferve to be taken notice of among the other



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Observ.

other microscopical feeds of Vegetables: For first, though they grow in a Cafe or Hive oftentimes bigger then one of these Pictures of the microfcopical appearance, yet are they for the most part fo very little, that they exceed not the bulk of a small Nitt, being not above 1/2 part of an Inch in Diameter, whereas the Diameter of the Hive of them oftentimes exceeds two Inches, so that it is capable of containing neer two hundred thousand, and fo in all likelihood does contain a vaft quantity, though perhaps not that number. Next, for their prettinefs, they may be compar'd to any microfcopical feed I have yet feen; for they are of a dark brownish red colour, curioufly Honey-comb'd all over with a very pretty variety of Net-work, or a fmall kind of imbolment of very orderly rais'd ridges, the furface of them looking not unlike the infide of a Beev's ftomack. But that which makes it most confiderable of all, is, the medicinal virtues of it, which are fuch as are not afforded us by any Mineral preparation ; and that is for the procuring of fleep, a thing as neceffary to the well-being of a creature as his meat, and that which refreshes both the voluntary and rational faculties, which, whil's this affection has feis'd the body, are for the most part unmov'd, and at rest. And, methinks, Nature does feem to hint fome very notable virtue or excellency in this Plant from the curiofity it has beftow'd upon it. First, in its flower, it is of the highest fcarlet-Dye, which is indeed the prime and chiefeft colour, and has been in all Ages of the world most highly efteem'd : Next, it has as much curiofity fhew'd alfo in the hufk or cafe of the feed, as any one Plant I have yet met withall; and thirdly, the very feeds themfelves, the Microfcope discovers to be very curiously shap'd bodies; and lastly, Nature has taken fuch abundant care for the propagation of it, that one fingle feed grown into a Plant, is capable of bringing fome hundred thousands of feeds.

It were very worthy fome able man's enquiry whether the intention of Nature, as to the fecundary end of Animal and Vegetable fubftances might not be found out by fome fuch characters and notable imprefions as thefe, or from divers other circumftances, as the figure, colour, place, time of flourifhing, fpringing and fading, duration, tafte, fmell, $O \cdot c$. For if fuch there are (as an able *Phylician* upon good grounds has given me caufe to believe) we might then, infteed of ftudying Herbals (where fo little is deliver'd of the virtues of a Plant, and lefs of truth) have recourfe to the Book of Nature it felf, and there find the moft natural, ufefull, and moft effectual and fpecifick Medicines, of which we have amongft Vegetables, two very noble Inftances to incourage fuch a hope, the one of the Jefuite pomder for the cure of *intermitting Feavers*, and the other of the juice of *Poppy* for the curing the defect of fleeping.

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Observ. XXXI. Of Purslane-seed.

THe Seeds of Purstane feem of very notable shapes, appearing through the Microscope shap'd somewhat like a nautilus or Porcelane shell, as may be seen in the XX. scheme, it being a small body, coyl'd round in the manner of a Spiral; at the greater end whereof, which represents the mouth or orifice of the Shell, there is left a little white transparent fubstance, like a fkin, reprefented by BBBB, which feems to have been the place whereunto the stem was join'd. The whole surface of this Coclea or Shell, is cover'd over with abundance of little prominencies or buttons very orderly rang'd into Spiral rows, the shape of each of which seem'd much to refemble a Wart upon a mans hand. The order, variety, and curiofity in the shape of this little feed, makes it a very pleafant object for the Microscope, one of them being cut afunder with a very sharp Penknife, discover'd this carved Casket to be of a brownish red, and somewhat transparent substance, and manifested the infide to be fill'd with a whitifh green fubstance or pulp, the Bed wherein the seminal principle lies invelop'd.

There are multitudes of other feeds which in fhape reprefent or imitate the forms of divers other forts of Shells: as the feed of *scurvygrafs*, very much refembles the make of a *Concha Venerea*, a kind of Purcelane Shell; others reprefent feveral forts of larger fruits, fweat Marjerome and Pot-marjerome reprefent Olives. Carret feeds are like a cleft of a Coco-Nut Hufk; others are like Artificial things, as Succory feeds are like a Quiver full of Arrows, the feeds of *Amaranthus* are of an exceeding lovely fhape, fomewhat like an Eye: The fkin of the black and fhrivled feeds of Onyons and Leeks, are all over knobbed like a Seals fkin. Sorrel has a pretty black thining three-fquare feed, which is picked at both ends with three ridges, that are bent the whole length of it. It were almost endless to reckon up the feveral fhapes, they are fo many and fo va-

rious; Leaving them therefore to the curious observer, I shall proceed to theObservations on the parts of Animals.

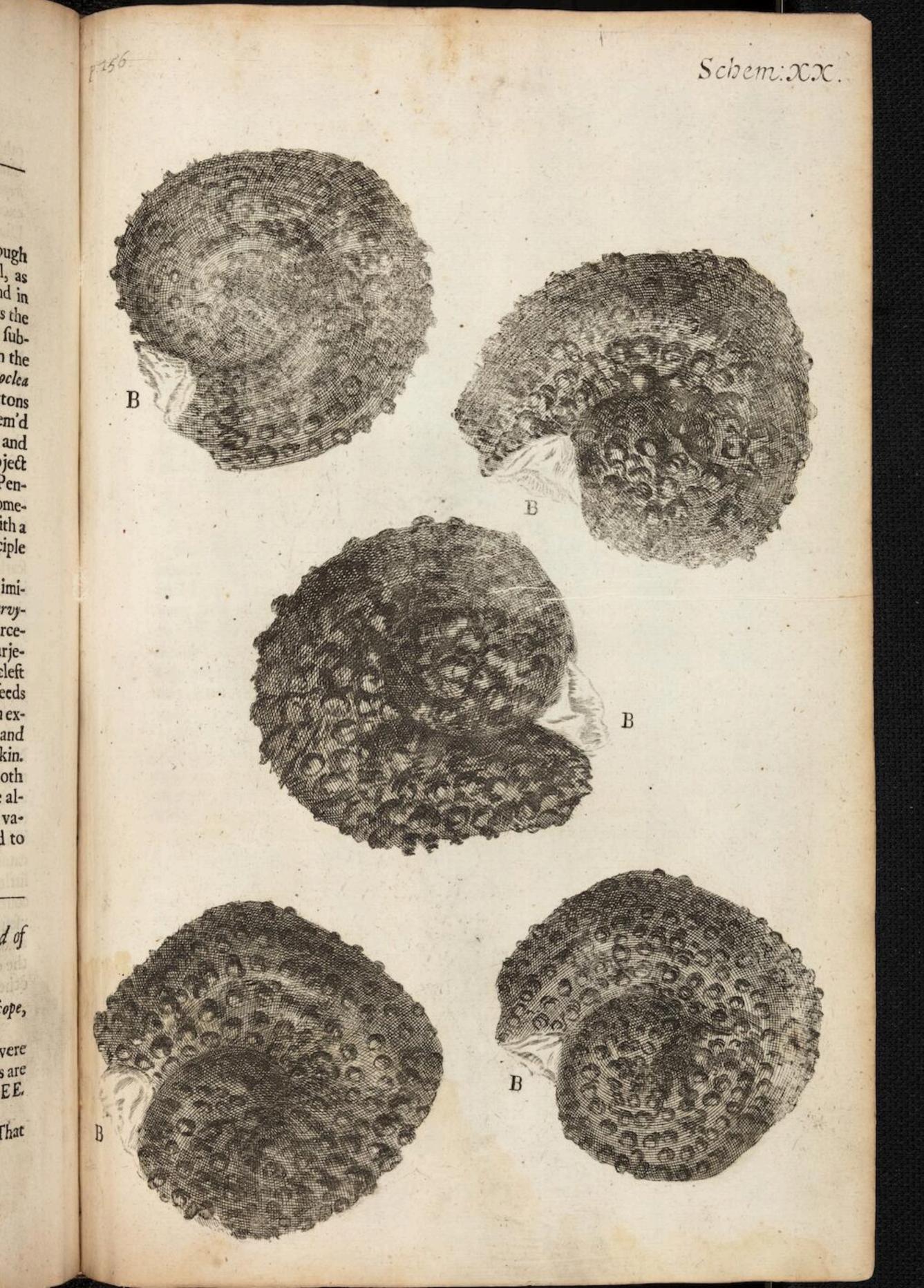
Observ. XXXII. Of the Figure of several forts of Hair, and of the texture of the skin.

VIewing fome of the Hairs of my Head with a very good Microfcope, I took notice of these particulars:

1. That they were, for the most part, Cylindrical, some of them were fomewhat Prifmatical, but generally they were veryneer round, such as are represented in the second Figure of the 5. scheme, by the Cylinder's EEE. nor could I find any that had sharp angules.

2. That

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2. That that part which was next the top, was bigger then that which was neerer the root.

3. That they were all along from end to end transparent, though not very cleer, the end next the root appearing like a black transparent piece of Horn, the end next the top more brown, somewhat like transparent Horn.

4. That the root of the Hairs were pretty fmooth, tapering inwards, almost like a Parsneb; nor could I find that it had any filaments, or any other vessels, such as the *fibres* of Plants.

5. That the top when fplit (which is common in long Hair) appear'd like the end of a ftick, beaten till it be all flitter'd, there being not onely two fplinters, but fometimes half a fcore and more.

6. That they were all, as farr as I was able to find, folid Cylindrical bodies, not pervious, like a Cane or Bulrufh; nor could I find that they had any Pith, or diffinction of Rind, or the like, fuch as I had observ'd in Horse-hairs, the Briftles of a Cat, the Indian Deer's Hair, &c.

Observations on several other sorts of Hair.

For the Brifles of a Hogg, I found them to be firft a hard transparent horny substance, without the least appearance of pores or holes in it; and this I try'd with the greatest care I was able, cutting many of them with a very sharp Razor, so that they appear'd, even in the Glass, to have a pretty smooth surface, but somewhat waved by the fawing to and fro of the Razor, as is visible in the end of the *Prismatical* body A of the fame Figure; and then making trials with causing the light to be cass on them all the various ways I could think of, that was likely to make the pores appear, if there had been any, I was not able to discover any.

Next, the Figure of the Brifles was very various, neither perfectly round, nor fharp edg'd, but *Prifmatical*, with divers fides, and round angles, as appears in the Figure A. The bending of them in any part where they before appear'd cleer, would all flaw them, and make them look white.

The Muftacheos of a Cat (part of one of which is reprefented by the fhort Cylinder B of the fame Figure) feem'd to have, all of them that I obferv'd, a large pith in the middle, like the pith of an Elder, whofe texture was fo clofe, that I was not able to difcover the leaft fign of pores; and those parts which feem to be pores, as they appear'd in one position to the light, in another I could find a manifest reflection to be cast from them.

This I inftance in, to hint that it is not fafe to conclude any thing to be politively this or that, though it appear never fo plain and likely when look'd on with a *Microscope* in one posture, before the fame be examin'd by placing it in feveral other positions.

And this I take to be the reafon why many have believed and afferted the Hairs of a man's head to be hollow, and like fo many fmall pipes perforated from end to end.

Now, though I grant that by an Analogie one may suppose them fo, and

and from the *Polonian* difease one may believe them such, yet I think we have not the least encouragement to either from the *Microscope*, much less positively to affert them such. And perhaps the very effence of the *Plica Polonica* may be the hairs growing hollow, and of an unnatural constitution.

And as for the Analogie, though I am apt enough to think that the hairs of feveral Animals may be perforated fomewhat like a Cane, or at leaft have a kind of pith in them, first, because they seem as 'twere a kind of Vegetable growing on an Animal, which growing they fay, remains a long while after the Animal is dead, and therefore should like other Vegetables have a pith ; and fecondly, because Horns and Feathers, and Porcupine's Quils, and Cats Brifles, and the long hairs of Horfes, which come very neer the nature of a mans hair, seem all of them to have a kind of pith, and fome of them to be porous, yet I think it not (in these cafes, where we have fuch helps for the fense as the Microscope affords) fafe concluding or building on more then we fenfibly know, fince we may, with examining, find that Nature does in the make of the fame kind of fubftance, often vary her method in framing of it : Instances enough to confirm this we may find in the Horns of feveral creatures : as what a vaft difference is there between the Horns of an Oxe, and those of some forts of Staggs as to their shape? and even in the hairs of several creatures, we find a vast difference; as the hair of a man's head seems, as I said before, long, Cylindrical and sometime a little Prismatical, solid or impervious, and very fmall; the hair of an Indian Deer (a part of the middle of which is defcribed in the third Figure of the fifth scheme, marked with F) is bigger in compass through all the middle of it, then the Brifle of an Hogg, but the end of it is smaller then the hair of any kind of Animal (as may be feen by the Figure G) the whole belly of it, which is about two or three Inches long, looks to the eye like a thread of course Canvals, that has been newly unwreath'd, it being all wav'd or bended to and fro, much after that manner, but through the Microscope, it appears all perforated from fide to fide, and Spongie, like a small kind of spongy Coral, which is often found upon the English shores; but though I cut it transversly, I could not perceive that it had any pores that ran the long-way of the hair: the long hairs of Horfes CC and D, feem Cylindrical and fomewhat pithy; the Brilles of a Cat B, are conical and pithy: the Quils of Porcupines and Hedghoggs, being cut transverfly, have a whitish pith, in the manner of a Starr, or Spur-rowel : Piggs-hair (A) is fomewhat triagonal, and feems to have neither pith nor pore: And other kinds of hair have quite a differing structure and form. And therefore I think it no way agreeable to a true natural Hiftorian, to pretend to be fo sharp-fighted, as to fee what a pre-conceiv'd Hypothesis tells them should be there, where another man, though perhaps as feeing, but not forestall'd, can discover no fuch matter.

throughout those hai Dyc-fat, Horn, th that it fin mix'd an thought Horn W1 water w especiall that are be dyed to hot lie ments, O have a n next, be then the Firft, be glutino body, Next, b fubltan bottom is no gr ly molt And we and fo kinds w but a d amolt two be of Cryf cave fic that inco and per

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But to proceed; I observ'd several kind of hairs that had been Dyed, and found them to be a kind of horny Cylinder, being of much about the transparency of a pretty cleer piece of Oxe horn; these appear'd quite through-

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throughout ting'd with the colours they exhibited. And 'tis likely, that those hairs being boyl'd or steep'd in those very hot ting'd liquors in the Dye-fat, And the substance of the hair being much like that of an Oxes Horn, the penetrant liquor does fo far mollifie and foften the fubftance; that it finks into the very center of it, and fo the ting'd parts come to be mix'd and united with the very body of the hair, and do not (as fome have thought) only flick on upon the outward furface. And this, the boiling of Horn will make more probable; for we shall find by that action, that the water will infinuate it felf to a pretty depth within the furface of it; efpecially if this penetrancy of the water be much helped by the Salts that are usually mix'd with the Dying liquors. Now, whereas Silk may be dyed or ting'd into all kind of colours without boiling or dipping into hot liquors, I ghess the reason to be two-fold : First, because the filaments, or fmall cylinders of Silk, are abundantly fmaller and finer, and fo have a much lefs depth to be penetrated then most kind of hairs; and next, because the substance or matter of Silk, is much more like a Glew then the substance of Hair is. And that I have reason to suppose: First, because when it is spun or drawn out of the Worm, it is a perfect glutinous fubftance, and very eafily fricks and cleaves to any adjacent body, as I have feveral times observed, both in Silk-worms and Spiders. Next, because that I find that water does easily diffolve and mollifie the fubItance again, which is evident from their manner of ordering those bottoms or pods of the Silk-worm before they are able to unwind them. It is no great wonder therefore, if those Dyes or ting d liquors do very quickly mollifie and tinge the furfaces of fo fmall and fo glutinous a body. And we need not wonder that the colours appear to lovely in the one, and fo dull in the other, if we view but the ting'd cylinders of both kinds with a good Microscope; for whereas the fubitance of Hair at beft, is but a dirty dufkish white somewhat transparent, the filaments of Silk have a most lovely transparency and cleerness, the difference between those two being not much lefs then that between a piece of Horn, and a piece of Cryftal; the one yielding a bright and vivid reflection from the concave fide of the cylinder, that is, from the concave furface of the Air that incompaties the back-part of the cylinder; the other yielding a dull and perturb'd reflection from the feveral Heterogeneous parts that compole it. And this difference will be manifest enough to the eye, if you get a couple of fmall Cylinders, the fmaller of Crystal Glass, the other of Horn, and then varnishing them over very thinly with some transparent colour, which will represent to the naked eye much the same kind of object which is reprefented to it from the filaments of Silk and Hair by the help of the Microscope. Now, fince the threads of Silk and Serge are made up of a great number of these filaments, we may henceforth cease to wonder at the difference. From much the fame reafon proceeds the vivid and lovely colours of Feathers, wherein they very farr exceed the natural as well as Artificial colours of hair of which I fhall fay more in its proper place. The Teguments indeed of creatures are all of them adapted to the pesuliar use and convenience of that Animal which they inwrap; and very much

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much also for the ornament and beauty of it, as will be most evident to any one that shall attentively consider the various kinds of cloathings wherewith most creatures are by Nature invested and cover'd. Thus I have observed, that the hair or furr of those Northern white Bears that inhabite the colder Regions, is exceeding thick and warm : the like have I observ'd of the hair of a Greenland Deer, which being brought alive to London, I had the opportunity of viewing ; its hair was so exceeding thick, long and fost, that I could hardly with my hand, grass or take hold of his skin, and it feem'd so exceeding warm, as I had never met with any before. And as for the ornamentative use of them, it is most evident in a multitude of creatures, not onely for colour, as the Leopards, Cats, Rhein Deer, $\mathcal{O}c$. but for the start onely for colour, as the Leopards, Cats, Rhein other of the greater fort of terrestrial Animals, but is much more conspicuous, in the Vestments of Fishes, Birds, Infects, of which I shall by and by give fome Inftances.

As for the fkin, the *Microfcope* difcovers as great a difference between the texture of those feveral kinds of Animals, as it does between their hairs; but all that I have yet taken notice of, when tann'd or drefs'd, are of a Spongie nature, and feem to be conftituted of an infinite company of fmall long *fibres* or hairs, which look not unlike a heap of Tow or Okum; every of which *fibres* feem to have been fome part of a Muscle, and probably, whil'st the Animal was alive, might have its distinct function, and ferve for the contraction and relaxation of the fkin, and for the stretching and shrinking of it this or that way.

And indeed, without fuch a kind of texture as this, which is very like that of spunk, it would feem very strange, how any body fo strong as the Ikin of an Animal ufually is, and fo close as it feems, whil'ft the Animal is living, should be able to suffer so great an extension any ways, without at all hurting or dilacerating any part of it. But, fince we are inform'd by the Microscope, that it confists of a great many small filaments, which are implicated, or intangled one within another, almost no otherwise then the hairs in a lock of Wool, or the flakes in a heap of Tow, though not altogether fo loofe ; but the filaments are here and there twifted, as twere, or interwoven, and here and there they join and unite with one another, fo as indeed the whole fkin feems to be but one piece, we need not much wonder: And though these fibres appear not through a Microscope, exactly jointed and contex'd, as in Sponge; yet, as I formerly hinted, I am apt to think, that could we find fome way of discovering the texture of it, whil'st it invests the living Animal, or had some very easie way of separating the pulp or intercurrent juices, fuch as in all probability fill those Interstitia, without dilacerating, brufing, or otherwife spoiling the texture of it (as it feems to be very much by the ways of tanning and dreffing now us'd) we might discover a much more curious texture then I have hitherto been able to find; perhaps, somewhat like that of Sponges. That of Chamoife Leather is indeed very much like that of Spunk, fave onely that the filaments feem nothing neer fo even and round, nor altogether so small, nor has it so curious joints as spunk has, some of which I have have latel bodies ma are comm no, I fha they unde wasted an What t

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rately for But to fcope, plai as it does fubftance his medi dreffing: those poi foft fubft through at the b fluid med Norist alfo feen of Rofe can be, a other be the lowe prefently from the ferves its Now, the avola pores, of or lefs p lomewh ther; for Bays, Hol to free a But of morefull fuch as fe

have lately difcover'd like those of a Sponge, and perhaps all these three bodies may be of the same kind of substance, though two of them indeed are commonly accounted Vegetable (which, whether they be so or no, I shall not now dispute) But this seems common to all three, that they undergo a tanning or dreffing, whereby the interspers'd juices are wasted and wash'd away before the texture of them can be discover'd.

What their way is of dreffing, or curing Sponges, I confefs, I cannot learn; but the way of dreffing *spunk*, is, by boiling it a good while in a ftrong *Lixivium*, and then beating it very well; and the manner of dreffing Leather is fufficiently known.

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It were indeed extremely defirable, if fuch a way could be found whereby the Parenchyma or flefh of the Muscles, and several other parts of the bod, ymight be wash'd, or wasted clean away, without vitiating the form of the *fibrous* parts or vessells of it, for hereby the texture of those parts, by the help of a good *Microscope*, might be most accurately found.

But to digrefs no further, we may, from this difcovery of the Microfcope, plainly enough understand how the skin, though it looks so close as it does, comes to give a passage to so vast a quantity of excrementitious substances, as the diligent Sanctorius has excellently observed it to do, in his medicina statica; for it seems very probable, from the texture after drefsing, that there are an infinit of pores that every way pierce it, and that those pores are onely fill'd with some kind of juice, or some very pulpy soft substance, and thereby the state way almost as easily find a passage through such a fluid vehicle as the vaporous bubbles which are generated at the bottom of a Kettle of hot water do find a passage through that fluid medium into the ambient Air.

Nor is the skin of animals only thus pervious, but even those of vegetables alfo feem to be the fame; for otherwife I cannot conceive why, if two fprigs of Rofemary (for Inftance) be taken as exactly alike in all particulars as can be, and the one be fet with the bottom in a Glass of water, and the other be fet just without the Glass, but in the Air onely, though you ftop the lower end of that in the Air very carefully with Wax, yet shall it prefently almost wither, whereas the other that feems to have a supply from the subjacent water by its small pipes, or microscopical pores, preferves its greennefs for many days, and fometimes weeks. CHICLY DISE Now, this to me, feems not likely to proceed from any other caufe then the avolation of the juice through the fkin; for by the Wax, all those other pores, of the ftem are very firmly and closely ftop'd up. And from the more or less porousness of the skins or rinds of Vegetables may, perhaps, be fomewhat of the reafon given, why they keep longer green, or fooner wither; for we may observe by the bladdering and craking of the leaves of Bays, Holly, Laurel, O.c. that their fkins are very close, and do not fuffer to free a passage through them of the included juices. Wasterminated But of this, and of the Experiment of the Rofemary, I shall elfewhere more fully confider, it feeming to me an extreme luciferous Experiment, fuch as seems indeed very plainly to prove the Schematism or structure of

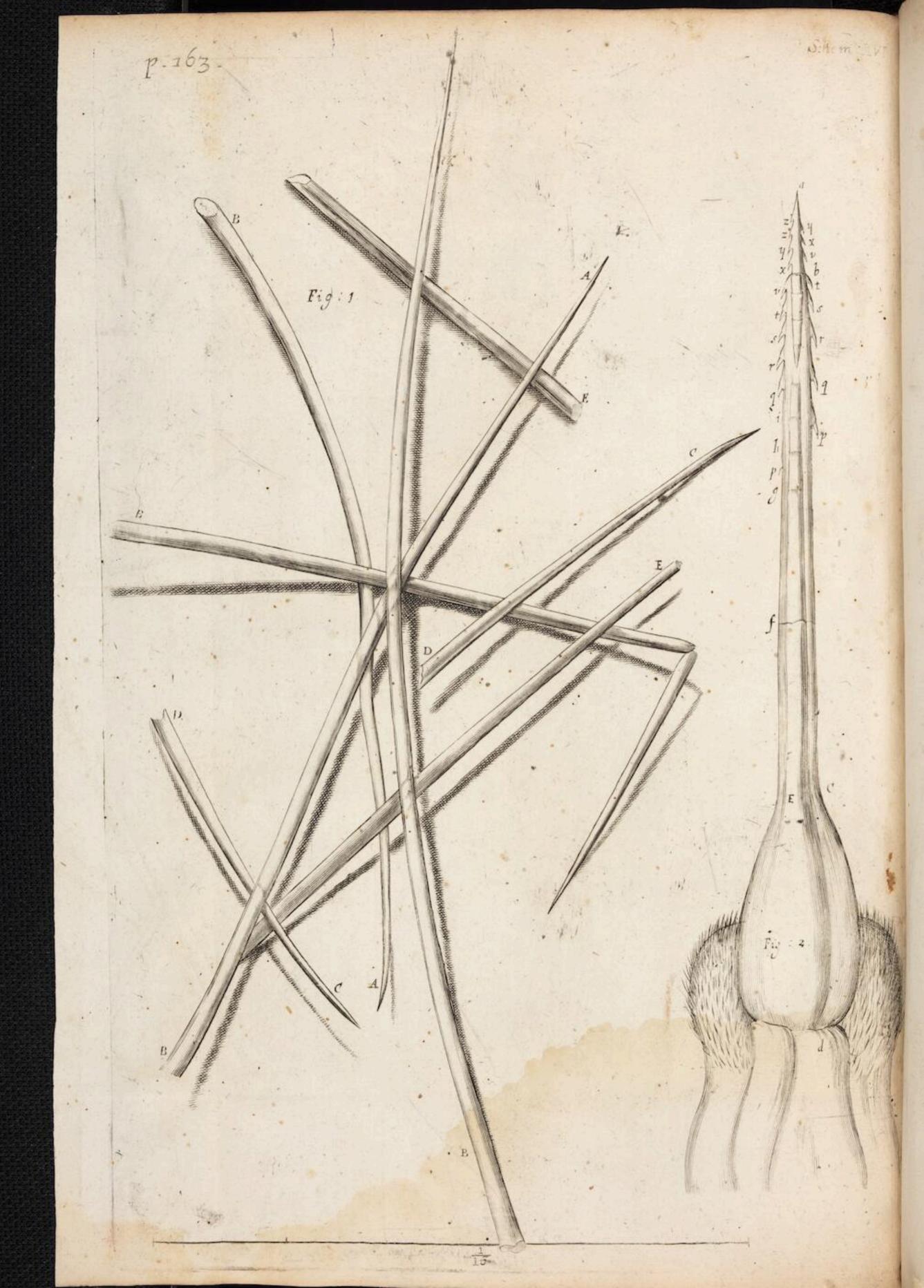
of Vegetables altogether mechanical, and as neceffary, that (water and warmth being apply'd to the bottom of the fprig of a Plant) fome of it fhould be carried upwards into the ftem, and thence diftributed into the leaves, as that the water of the *Thames* covering the bottom of the Mills at the Bridge foot of *London*, and by the ebbing aud flowing of it, paffling ftrongly by them, fhould have fome part of it convey'd to the Cefterns above, and thence into feveral houses and Cefterns up and down the City.

Observ. XXXIII. Of the Scales of a Soal, and other Fishes.

Aving hinted fomewhat of the fkin and covering of terrestrial Animals, I shall next add an Observation I made on the skin and Scales of a soal, a fmall Fifh, commonly enough known; and here in Fifhes, as well as other Animals, Nature follows its usual method, framing all parts fo, as that they are both usefull and ornamental in all its composures, mingling utile and dulce together; and both these defigns it seems to follow, though our unaffifted fenfes are not able to peceive them : This is not onely manifest in the covering of this Fish only, but in multitudes of others, which it would be too long to enumerate, witness particularly that fmall Sand Shell, which I mention'd in the XI. Observation, and infinite other small Shells and Scales, divers of which I have view'd. This skin I view'd, was flead from a prettylarge soal, and then expanded and dry'd, the infide of it, when dry, to the naked eye, look'd very like a piece of Canvafs, but the Microfcope discover'd that texture to be nothing elfe, but the inner ends of those curious Scolop'd Scales I, I, I, in the second Figure of the XXI. scheme, namely, the part of GGGG (of the larger reprefentation of a fingle Scale, in the first Figure of the fame Scheme) which on the back fide, through an ordinary fingle Magnifying Glafs, look'd not unlike the Tyles on an house.

The outfide of it, to the naked eye, exhibited nothing more of ornament, fave the ufual order of ranging the Scales into a triagonal form, onely the edges feem'd a little to fhine, the finger being rubb d from the tail-wards towards the head, the Scales feem'd to ftay and raze it; But through an ordinary Magnifying glafs, it exhibited a moft curioufly carved and adorned furface, fuch as is vifible in the fecond Figure, each of those (formerly almost imperceptible) Scales appearing much of the fhape I, I, I, that is, they were round, and protuberant, and fomewhat fhap'd like a Scolop, the whole Scale being creas'd with curioufly wav'd and indented ridges, with proportionable furrows between; each of which was terminated with a very fharp transparent bony fubstance, which, like fo many fmall Turnpikes, feem'd to arm the edges. The back part K K K was the fkin into which each of thefe Scales were very deeply fix'd, in the curious regular order, visible in the fecond *Figure*.





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Figure. The length and fhape of the part of the Scale which was buried by the fkin, is evidenced by the first Figure; which is the representation of one of them pluck'd out and view'd through a good *Microfcope*, namely, the part L FG GFL, wherein is also more plainly to be feen, the manner of carving of the feelopt part of every particular Scale, how each ridge or barr EEE is alternately hollowed or engraven, and how every gutter between them is terminated with very transparent and hard pointed fpikes, and how every other of these, as A A A A, are much longer then the interjacent ones, D D D.

The texture or form also of the hidden part appears, namely, the middle part, GGG, feems to confift of a great number of fmall quills or pipes, by which, perhaps, the whole may be nourifhed; and the fide parts FF confift of a more fibrous texture, though indeed the whole Scale feem'd to be of a very tough grifly fubftance, like the larger Scales of other Fishes.

The Scales of the fkin of a Dog-fifh (which is us'd by fuch as work in Wood, for the fmoothing of their work, and confifts plainly enough to the naked eye, of a great number of fmall horny points) through the *Microfcope* appear'd each of them curioufly ridg'd, and very neatly carved ; and indeed, you can hardly look on the fcales of any Fifh, but you may difcover abundance of curiofity and beautifying; and not only in thefe Fifhes, but in the fhells and crufts or armour of moft forts of *Marine* Animals fo invefted.

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Observ. XXXIV. Of the Sting of a Bee.

the top inwards, and thus, by an He Sting of a Bee, delineated in the fecond Figure of the XVI. Scheme. feems to be a weapon of offence, and is as great an Instance, that Nature did realy intend revenge as any, and that first, because there feems to be no other use of it. Secondly, by reason of its admirable shape, feeming to be purposely shap'd for that very end. Thirdly, from the virulency of the liquor it ejects, and the fad effects and fymptoms that follow it. But whatever be the use of it, certain it is, that the structure of it is very admirable; what it appears to the naked eye, I need not defcribe, the thing being known almost to every one, but it appears through the Microscope, to confift of two parts, the one a sheath, without a chape or top, shap'd almost like the Holster of a Pistol, beginning at d, and ending at b, this fheath I could most plainly perceive to be hollow, and to contain in it, both a Sword or Dart, and the poifonous liquor that caufes the pain. The fheath or cafe feem'd to have feveral joints or fettings together, marked by fg bik 1 mno, it was arm'd moreover neer the top, with feveral crooks or forks (pqrft) on one fide, and (pqrftu) on the other, each of which feem'd like fo many Thorns growing on a briar, or rather like fo many Cat's Claws; for the crooks themfelves feem'd to be little tharp transparent points or claws, growing out of little protuberancies on the L 2

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the fide of the fheath, which, by observing the Figure diligently, is easie enough to be perceiv'd; and from several particulars, I suppose the Animal has a power of displaying them, and shutting them in again as it pleases, as a Cat does its claws, or as an Adder or Viper can its teeth or fangs.

The other part of the Sting was the Sword, as 1 may fo call it, which is fheath'd, as it were, in it, the top of which *ab* appears quite through at the fmaller end, just as if the chape of the fheath of a Sword were loft, and the end of it appear'd beyond the Scabbard; the end of this Dart(*a*) was very fharp, and it was arm'd likewife with the like Tenterhooks or claws with those of the fheath, such as (vxy, xyzz) these crooks, I am very apt to think, can be clos'd up also, or laid flat to the fides of the Sword when it is drawn into the Scabbard, as I have feveral times observ'd it to be, and can be fpred again or extended when ever the Animal pleases.

The confideration of which very pretty ftructure, has hinted to me, that certainly the use of these claws feems to be very confiderable, as to the main end of this Instrument, for the drawing in, and holding the fring in the flesh; for the point being very sharp, the top of the Sting or Dagger (ab) is very eafily thrust into an Animal's body, which being once entred, the Bee, by endeavouring to pull it into the fheath, draws (by reafon of the crooks (vxy) and (xyzz) which lay hold of the fkin on either fide) the top of the fleath $(t \int r v)$ into the fkin after it, and the crooks t, s, and r, v, being entred, when the Bee endeavours to thrust out the top of the sting out of the sheath again, they lay hold of the skin on either fide, and fo not onely keep the fheath from fliding back, but helps the top inwards, and thus, by an alternate and fucceflive retracting and emitting of the Sting in and out of the fheath, the little enraged creature by degrees makes his revengfull weapon pierce the toughest and thickest Hides of his enemies, in fo much that fome few of these stout and refolute foldiers with these little engines, do often put to flight a huge masty Bear, one of their deadly enemies, and thereby fhew the world how much more confiderable in Warr a few skilfull Engineers and resolute foldiers politickly order'd, that know how to manage fuch engines, are, then a valt unweildy rude force, that confides in, and acts onely by, its strength. But (to proceed) that he thus gets in his Sting into the skin, I conjecture, because, when I have observ'd this creature living, I have found it to move the Sting thus, to and fro, and thereby also, perhaps, does, as 'twere, pump or force out the poilonous liquor, and make it hang at the end of the fheath about b in a drop. The crooks, I suppose alfo to be the caufe why these angry creatures, hastily removing themfelves from their revenge, do often leave these weapons behind them, sheath'd, as 'twere, in the fiesh, and, by that means, cause the painfull fymptoms to be greater, and more lafting, which are very probably caus'd, partly by the piercing and tearing of the fkin by the Sting, but chiefly by the corrofive and poifonous liquor that is by this Syringe-pipe convey'd among the fenfitive parts thereof and thereby more eatily gnaws and

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and corrodes those tender *fibres*: As I have shewed in the description of a Nettle and of Cowhage.

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Observ. XXXV. Of the contexture and shape of the particles of Feathers.

E in all forts of wing-Feathers, especially in those which ferv'd for the beating of the air in the action of flying.

That the outward furface of the Quill and Stem was of a very hard, ftiff, and horny fubftance, which is obvious enough, and that the part above the Quill was fill d with a very white and light pith, and, with the *Microfcope*, I found this pith to be nothing elfe, but a kind of natural *congeries* of fmall bubbles, the films of which feem to be of the fame fubftance with that of the Quill, that is, of a ftiff transparent horny fubftance.

Which particular feems to me, very worthy a more ferious confideration; For here we may obferve Nature, as 'twere, put to its fhifts, to make a fubftance, which fhall be both light enough, and very ftiff and ftrong, without varying from its own eftablished principles, which we may obferve to be fuch, that very ftrong bodies are for the most part very heavie alfo, a ftrength of the parts ufually requiring a density, and a density a gravity; and therefore fhould Nature have made a body fo broad and fo ftrong as a Feather, almost, any other way then what it has taken, the gravity of it must necessarily have many times exceeded this; for this pith feems to be like fo many ftops or cross pieces in a long optical tube, which do very much contribute to the ftrength of the whole, the pores of which were fuch, as that they feem'd not to have any communication with one another, as I have elsewhere hinted.

But the Mechanism of Nature is usually so excellent, that one and the same substance is adapted to serve for many ends. For the chief use of this, indeed, feems to be for the fupply of nourifhment to the downy or feathery part of the ftem; for 'tis obvious enough in all forts of Feathers, that 'tis plac'd just under the roots of the branches that grow out of either fide of the quill or ftalk, and is exactly fhap'd according to the ranking of those branches, coming no lower into the quill, then just the beginning of the downy branches, and growing onely on the under fide of of the quill where those branches do fo. Now, in a ripe Feather (as one may call it) it feems difficult to conceive how the Succus nutritius should be convey'd to this pith; for it cannot, I think, be well imagin'd to pass through the fubstance of the quill, fince, having examin'd it with the greatest diligence I was able, I could not find the least appearance of pores; but he that thall well examine an unripe or pinn'd Feather, will plainly enough perceive the Veffel for the conveyance of it to be the thin filmy pith (as tis call'd) which paffes through the middle of the quill. As for the make and contexture of the Down it felf, it is indeed very rare

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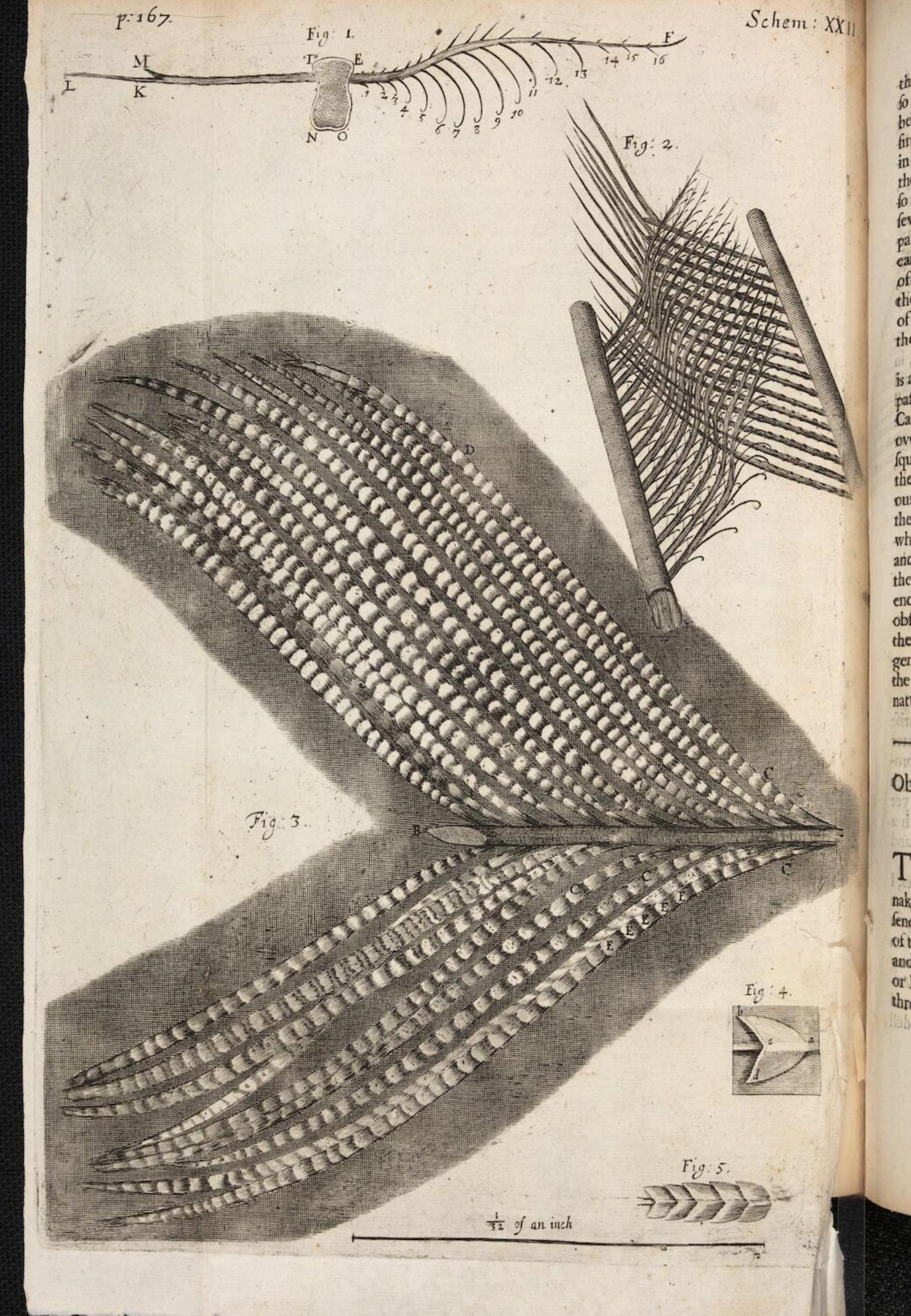
MICROGRAPHIA.

rare and admirable, and fuch as I can hardly believe, that the like is to be discover'd in any other body in the world; for there is hardly a large Feather in the wing of a Bird, but contains neer a million of diffinct parts, and every one of them shap'd in a most regular & admirable form, adapted to a particular Defign : For examining a middle ciz'd Goofe-quill, I eafily enough found with my naked eye, that the main ftem of it contain'd about 300. longer and more Downy branchings upon one fide, and as many on the other of more stiff but somewhat shorter branchings. Many of these long and downy branchings, examining with an ordinary Microscope, I found divers of them to contain neer 1200. small leaves (as I may call them, fuch as EF of the first Figure of the 23. Scheme) and as many stalks ; on the other fide, fuch as IK of the fame Figure, each of the leaves or branchings, E F, feem'd to be divided into about fixteen or eighteen small joints, as may be seen plainly enough in the Figure, out of most of which there seem to grow small long fibres, such as are express'd in the Figure, each of them very proportionably fhap'd according to its polition, or plac'd on the stalk E F; those on the under fide of it, name-Iy, 1, 2, 3, 4, 5, 6, 7, 8, 9, 6.c. being much longer then those directly oppolite to them on the upper ; and divers of them, fuch as 2,3,4,5,6,7,8,9, &c. were terminated with fmall crooks, much refembling those fmall crooks, which are visible enough to the naked eye, in the feed-buttons of Bur-docks. The stalks likewife, IK on the other fide, feem'd divided into neer as many small knotted joints, but without any appearance of strings or crooks, each of them about the middle K, feem'd divided into two parts by a kind of fork, one fide of which, namely, K L, was extended neer the length of KI, the other, M, was very fhort.

The transverse Sections of the stems of these branchings, manifested the shape or figure of it to be much like INOE, which confisted of a horny fkin or covering, and a white feemingly frothy pith, much like the make of the main stem of a Feather.

The use of this strange kind of form, is indeed more admirable then all the reft, and fuch as deferves to be much more ferioufly examin'd and confider'd, then I have hitherto found time or ability to do; for certainly, it may very much instruct us in the nature of the Air, especially as to fome properties of it.

The stems of the Downy branches INOE, being rang'd in the order visible enough to the naked eye, at the distance of IF, or somewhat more, the collateral stalks and leaves (if I may fo call those bodies I newly described) are so rang'd, that the leaves or hairy stalks of the one fide lie at top, or are incumbent on the stalks of the other, and cross each . other, much after the manner express'd in the second Figure of the 23. scheme, by which means every of those little hooked fibres of the leaved stalk get between the naked stalks, and the stalks being full of knots, and a prety way dif-join'd, fo as that the fibres can eafily get between them, the two parts are fo clofely and admirably woven together, that it is able to impede, for the greatest part, the transcursion of the Air; and though they are fo exceeding fmall, as that the thickness of one of thefe



Schem: W

these ftalks amounts not to a 500. part of an Inch, yet do they compose fo ftrong a texture, as, notwithstanding the exceeding quick and violent beating of them against the Air, by the strength of the Birds wing, they firmly hold together. And it argues an admirable providence of Nature in the contrivance and fabrick of them; for their texture is such, that though by any external injury the parts of them are violently dif-joyn'd, fo as that the leaves and stalks touch not one another, and confequently feveral of these rents would impede the Bird's flying; yet, for the most part, of themselves they readily re-join and re-contex themselves, and are easily by the Birds stroking the Feather, or drawing it through its Bill, all of them settled and woven into their former and natural posture; for there are such an infinite company of those small *fibres* in the under side of the leaves, and most of them have such little crooks at their ends, that they readily catch and hold the stalks they touch.

From which strange contexture, it feems rational to suppose that there is a certain kind of meth or hole to fmall, that the Air will not very eafily pafs through it, as I hinted also in the fixth Observation about small Glass Canes, for otherwise it feems probable, that Nature would have drawn over fome kind of thin film which fhould have covered all those almost fquare methes or holes, there feeming through the Microfcope to be more then half of the furface of the Feather which is open and vifibly pervious; which conjecture will yet feem more probable from the texture of the brushie wings of the Tinea argentea, or white Feather wing'd moth, which I shall anone describe. But Nature, that knows best its own laws, and the feveral properties of bodies, knows also best how to adapt and fit them to her defigned ends, and whofo would know those properties, must endeavour to trace Nature in its working, and to fee what courfe fhe observes. And this I suppose will be no inconfiderable advantage which the Schematifms and Structures of Animate bodies will afford the diligent enquirer, namely, most fure and excellent instructions, both as to the practical part of Mechanicks and to the Theory and knowledge of the nature of the bodies and motions. Now, that thele colours are onely fantafiead ones, that is, fuch as arife

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Observ. XXXVI. Of Peacoks, Ducks, and other Feathers of changeable colours.

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wetting thele colour d parts, dolbroy'd their colours, which teem'd to pro-

The parts of the Feathers of this glorious Bird appear, through the *Microfcope*, no lefs gaudy then do the whole Feathers; for, as to the naked eye 'tis evident that the ftem or quill of each Feather in the tail fends out multitudes of *Lateral* branches, fuch as AB in the third Figure of the 23. *Scheme* reprefents a fmall part of about $\frac{1}{32}$ part of an Inch long, and each of the *lateral* branches emit multitudes of little fprigs, threads or hairs on either fide of them, fuch as CD, CD, CD, fo each of those threads in the *Microfcope* appears a large long body, confifting of a multitude

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tude of bright reflecting parts, whole Figure 'tis no easie matter to determine, as he that examines it shall find; for every new position of it to the light makes it perfectly feem of another form and shape, and nothing what it appear'd a little before; nay, it appear'd very differing ofttimes from so feemingly inconfiderable a circumstance, that the interposing of ones hand between the light and it, makes a very great change, and the opening or shutting a Casement and the like, very much diversifies the appearance. And though, by examining the form of it very many ways, which would be tedious here to enumerate, I suppose I have difcover'd the true Figure of it, yet oftentimes, upon looking on it in another posture, I have almost thought my former observations deficient, though indeed, upon further examination, I have found even those also to confirm them.

These threads therefore I find to be a congeries of small Lamina or plates, as e e e e e, &c. each of them shap'd much like this of a b c d, in the fourth Figure, the part a c being a ridge, prominency, or stem, and b and d the corners of two small thin Plates that grow unto the small stalk in the middle, fo that they make a kind of little feather; each of these Plates lie one close to another, almost like a company of floping ridge or gutter Tyles; they grow on each fide of the stalk opposite to one another, by two and two, from top to bottom, in the manner express'd in the fifth Figure, the tops of the lower covering the roots of the next above them; the under fide of each of these laminated bodies, is of a very dark and opacous substance, and suffers very few Rays to be trajected, but reflects them all toward that fide from whence they come, much like the foil of a Looking-glas; but their upper fides feem to me to confift of a multitude of thin plated bodies, which are exceeding thin, and lie very close together, and thereby, like mother of Pearl shells, do not onely reflect a very brifk light, but tinge that light in a most curious manner; and by means of various politions, in respect of the light, they reflect back now one colour, and then another, and those most vividly.

Now, that these colours are onely fantastical ones, that is, such as arise immediately from the refractions of the light, I found by this, that water wetting these colour'd parts, destroy'd their colours, which seem'd to proceed from the alteration of the reflection and refraction. Now, though I was not able to fee those hairs at all transparent by a common light, yet by looking on them against the Sun, I found them to be ting'd with a darkish red colour, nothing a-kin to the curious and lovely greens and blues they exhibited. What the reason of colour seems to be in such thin plated bodies, I have elsewhere shewn. But how water cast upon those threads destroys their colours, I suppose to be perform'd thus; The water falling upon these plated bodies from its having a greater congruity to Feathers then the Air, infinuates it felf between those Plates, and so extrudes the strong reflecting Air, whence both these parts grow more transparent, as the Microscope informs, and colourless also, at best retaining a very faint and dull



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dull colour. But this wet being walted away by the continual evaporations and fteams that pais through them from the Peacock, whil'ft that Bird is yet alive, the colours again appear in their former lufter, the *interftitia* of these Plates being fill'd with the ftrongly reflecting Air.

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The beauteous and vivid colours of the Feathers of this Bird, being found to proceed from the curious and exceeding imalnels and finenels of the reflecting parts, we have here the reason given us of all those gauderies in the apparel of other Birds alfo, and how they come to exceed the colours of all other kinds of Animals, befides Infects; for fince (as we here and elfewhere also thew) the vividness of a colour, depends upon the finenels and transparency of the reflecting and refracting parts 3 and fince our Microfcope discovers to us, that the component parts of feathers are fuch, and that the hairs of Animals are otherwise; and fince we find alfo by the Experiment of that Noble and most Excellent Person I formerly named ; that the difference between Silk and Flax, as to its colour, is nothing elfe (for Flax reduc'd to a very great finenels of parts, both white and colour'd, appears as white and as vivid as any Silk, but lofes that brightness and its Silken aspect as foon as it is twifted into thread, by reason that the component parts, though very small and fine, are yet pliable flakes, and not cylinders, and thence, by twifting, become united into one opacous body, whereas the threads of Silk and Feathers retain their luftre, by preferving their cylindrical form intire without mixing; fo that each reflected and refracted beam that composes the gloss of Silk, preferves its own property of modulating the light intire); And fince we find the fame confirm'd by many other Experiments elfewhere mentioned, I think we may fafely conclude this for an Axiome, that wherefoever we meet with transparent bodies, spun out into very fine parts, either cleer, or any ways ting'd, the colours refulting from fuch a composition must necessarily be very glorious, vivid, and cleer, like those of Silk and Feathers. This may perhaps hint fome usefull way of making other bodies, befides Silk, be fusceptible of bright tinctures, but of this onely by the by.

The changeable colour'd Feathers also of Ducks, and several other Birds, I have found by examination with my Microscope, to proceed from

much the fame caufes and textures.

Observ. XXXVII. Of the Feet of Flies, and several other Insects.

The foot of a Fly (delineated in the first Figure of the 23. scheme, which represents three joints, the two Tallons, and the two Pattens in a flat posture; and in the second Figure of the same scheme, which represents onely one joint, the Tallons and Pattens in another posture) is of a most admirable and curious contrivance, for by this the Flies are inabled to walk against the sides of Glass, perpendicularly upwards, and to A a contain

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contain themfelves in that pofture as long as they pleafe;nay, to walk and fufpend themfelves againft the under furface of many bodies, as the ceiling of a room, or the like, and this with as great a feeming facility and firmnefs, as if they were a kind of *Antipodes*, and had a *tendency* upwards, as we are fure they have the contrary, which they alfo evidently difcover, in that they cannot make themfelves fo light, as to ftick or fufpend themfelves on the under furface of a Glafs well polifh'd and cleans'd; their fufpenfion therefore is wholly to be afcrib'd to fome Mechanical contrivance in their feet; which, what it is, we fhall in brief explain, by fhewing, that its Mechanifm confifts principally in two parts, that is, firft its two Claws, or Tallons, and fecondly, two Palms, Pattens, or Soles.

The two Tallons are very large, in proportion to the foot, and handfomly fhap'd in the manner defcrib'd in the Figures, by AB, and AC, the bigger part of them from A to dd, is all hairy, or brifled, but toward the top, at C and B fmooth, the tops or points, which feem very fharp turning downwards and inwards, are each of them mov'd on a joint at A, by which the Fly is able to open or fhut them at pleafure, fo that the points B and C being entered in any pores, and the Fly endeavouring to fhut them, the Claws not onely draw one againft another, and fo faften each other, but they draw the whole foot, G G A D D forward, fo that on a foft footing, the tenters or points G G G G, (whereof a Fly has about ten in each foot, to wit, two in every joint) run into the pores, if they find any, or at leaft make their way; and this is fenfible to the naked eye, in the feet of a *Chafer*, which, if he be fuffer'd to creep over the hand, or any other part of the fkin of ones body, does make his fteps as fenfible to the touch as the fight.

But this contrivance, as it often fails the *Chafer*, when he walks on hard and clofe bodies, fo would it alfo our Fly, though he be a much leffer, and nimbler creature, and therefore Nature has furnish'd his foot with another *additament* much more curious and admirable, and that is, with a couple of Palms, Pattens or Soles DD, the structure of which is this:

From the bottom or under part of the last joint of his foot, K, arife two small thin plated horny substances, each confisting of two flat pieces, D D, which feem to be flexible, like the covers of a Book, about F F, by which means, the plains of the two fides E E, Ido not always lie in the fame plain, but may be fometimes fhut clofer, and fo each of them may take a little hold themselves on a body; but that is not all, for the under fides of these Soles are all beset with small brifles, or tenters, like the Wire teeth of a Card used for working Wool, the points of all which tend forwards, hence the two Tallons drawing the feet forwards, as I before hinted, and these being applied to the surface of the body with all the points looking the contrary way, that is, forwards and outwards, if there be any irregularity or yielding in the furface of the body, the Fly fufpends it felfvery firmly and eafily, without the access or need of any fuch Sponges fill'd with an imaginary gluten, as many have, for want of good Glasses, perhaps, or a troublesome and diligent examination, supposed. Now, that the Fly is able to walk on Glass, proceeds partly from some ruggedneis

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ruggedness of the surface; and chiefly from a kind of tarnish, or dirty smoaky substance, which adheres to the surface of that very hard body; and though the pointed parts cannot penetrate the substance of Glass, yet may they find pores enough in the tarnish, or at least make them.

This Structure I fomewhat the more diligently furvey'd, becaufe I could not well comprehend, how, if there were fuch a glutinous matter in those fupposed Sponges, as most (that have observ'd that Object in a *Microscope*) have hitherto believ'd, how, I fay, the Fly could fo readily unglew and loosen its feet: and, because I have not found any other creature to have a contrivance any ways like it; and chiefly, that we might not be cast upon unintelligible explications of the *Phænomena* of Nature, at least others then the true ones, where our fenses were able to furnish us with an intelligible, rationall and true one.

Somewhat a like contrivance to this of Flies shall we find in most other Animals, such as all kinds of Flies and cafe-wing'd creatures; nay, in a Flea, an Animal abundantly smaller then this Fly. Other creatures, as Mites, the Land-Crab, &c. have onely one small very sharp Tallon at the end of each of their legs, which all drawing towards the center or middle of their body, inable these exceeding light bodies to suffered and fasten themselves to almost any surface.

Which how they are able to do, will not feem ftrange, if we confider, first, how little body there is in one of these creatures compar'd to their superficies, or outfide, their thickness, perhaps, oftentimes, not amounting to the hundredth part of an Inch: Next, the ftrength and agility of these creatures compar'd to their bulk, being, proportionable to their bulk, perhaps, an hundred times ftronger then an Horfe or Man. And thirdly, if we confider that Nature does always appropriate the inftruments, fo as they are the most fit and convenient to perform their offices, and the most simple and plain that possibly can be ; this we may see further verify'd alfo in the foot of a Loufe which is very much differing from those I have been deferibing, but more convenient and neceflary for the place of its habitation, each of his leggs being footed with a couple of fmall claws which he can open or fhut at pleasure, shap'd almost like the claws of a Lobster or Crab, but with appropriated contrivances for his peculiar ule, which being to move its body to and fro upon the hairs of the creature it inhabits, Nature has furnish'd one of its claws with joints, almost like the joints of a man's fingers, fo as thereby it is able to encompass or grafp a hair as firmly as a man can a flick or rope. inning, if one may one Nor, is there a lefs admirable and wonderfull Mechanism in the foot of a Spider, whereby he is able to fpin, weave, and climb, or run on his curious transparent clew, of which I shall say more in the description of of the wings moving betweeen them. it that Animal. And to conclude, we shall in all things find, that Nature does not onely work Mechanically, but by fuch excellent and most compendious, as well as stupendious contrivances, that it were impossible for all the reason in the world to find out any contrivance to do the fame thing that thould have more convenient properties. And can any be to lottifh, 28 Aa 2

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as to think all those things the productions of chance? Certainly, either their Ratiocination must be extremely depraved, or they did never attentively confider and contemplate the Works of the Al-mighty.

Observ. XXXVIII. Of the Structure and motion of the Wings of Flies.

The Wings of all kinds of Infects, are, for the most part, very beautifull Objects and afford no less pleasing an Object to the mind beautifull Objects, and afford no less pleasing an Object to the mind to speculate upon, then to the eye to behold. This of the blue Fly, among the reft, wants not its peculiar ornaments and contrivances ; it grows out of the Thorax, or middle part of the body of a Fly, and is feated a little beyond the center of gravity in the body towards the head, but that Excentricly is curioufly balanc'd ; first, by the expanded Area of the wings which lies all more backwards then the root, by the motion of them, whereby the center of their vibration is much more backwards towards the tail of the Fly then the root of the wing is. What the vibrative motion of the wings is, and after what manner they are moved, I have endeavoured by many trials to find out : And for the first manner of their motion, I endeavoured to observe several of those kind of small fpinning Flies, which will naturally fuspend themfelves, as it were, pois'd and fteady in one place of the air, without rifing or falling, or moving forwards or backwards; for by looking down on those, I could by a kind of faint shadow, perceive the utmost extremes of the vibrative motion of their wings, which fhadow, whil'ft they fo endeavoured to fufpend themfelves, was not very long, but when they endeavour'd to flie forwards, it was fomewhat longer; next, I tried, it, by fixing the leggs of a Fly upon the top of the stalk of a feather, with Glew, Wax, &c. and then making it endeavour to flie away; for being thereby able to view it in any posture, I collected that the motion of the wing was after this manner. The extreme limits of the vibrations were usually fomewhat about the length of the body diftant from one another, oftentimes fhorter, and fometimes also longer; that the formost limit was usually a little above the back, and the hinder form what beneath the belly ; between which two limits, if one may ghess by the found, the wing feem'd to be mov'd forwards and backwards with an equal velocity : And if one may (from the fhadow or faint reprefentation the wings afforded, and from the confideration of the nature of the thing) ghess at the posture or manner of the wings moving betweeen them, it feem'd to be this: The wing being fuppos'd placed in the upmost limit, seems to be put so that the plain of it lies almost horizontal, but onely the forepart does dip a little, or is fomewhat more deprest; in this position is the wing vibrated or mov'd to the lower limit, being almost arrived at the lower limit, the hinder part of the wing moving somewhat faster then the former,

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former, the Area of the wing begins to dip behind, and in that posture feems it to be mov'd to the upper limit back again, and thence back again in the first posture, the former part of the Area dipping again, as it is moved downwards by means of the quicker motion of the main stem which terminates or edges the forepart of the wing. And these vibrations or motions to and fro between the two limits feem fo fwift, that 'tis very probable (from the found it affords, if it be compar'd with the vibration of a mufical ftring, tun'd unifon to it) it makes many hundreds, if not fome thousands of vibrations in a fecond minute of time. And, if we may be allow'd to ghess by the found, the wing of a Bee is yet more fwift, for the tone is much more acute, and that, in all likelihood, proceeds from the exceeding fwift beating of the air by the fmall wing. And it feems the more likely too, becaufe the wing of a Bee is lefs in proportion to its body, then the other wing to the body of a Fly; fo that for ought I know, it may be one of the quickeft vibrating spontaneous motions of any in the world; and though perhaps there may be many Flies in other places that afford a yet more shrill noise with their wings, yet 'tis most probable that the quickest vibrating spontaneous motion is to be found in the wing of some creature. Now, if we confider the exceeding quickness of these Animal spirits that must cause these motions, we cannot chufe but admire the exceeding vividness of the governing faculty or Anima of the Infect, which is able to difpose and regulate so the the motive faculties, as to caufe every peculiar organ, not onely to move or act fo quick, but to do it also fo regularly.

Whil'ft I was examining and confidering the curious Mechanism of the wings, I observed that under the wings of most kind of Flies, Bees, Oc. there were plac'd certain pendulums or extended drops (as I may fo call them from their refembling motion and figure) for they much refembled a long hanging drop of fome transparent viscous liquor; and I observed them conftantly to move just before the wings of the Fly began to move, fo that at the first fight I could not but ghess, that there was some excellent use, as to the regulation of the motion of the wing, and did phancy, that it might be fomething like the handle of a Cock, which by vibrating to and fro, might, as 'twere, open and fhut the Cock, and thereby give a paffage to the determinate influences into the Muscles; afterwards,upon fome other trials, I fuppos'd that they might be for fome use in respiration, which for many reafons I suppose those Animals to use, and, me thought, it was not very improbable, but that they might have convenient passages under the wings for the emitting, at least, of the air, if not admitting, as in the gills of Fishes is most evident; or, perhaps, this Pendulum might be fomewhat like the staff to a Pump, whereby these creatures might exercise their Analogus lungs, and not only draw in, but force out, the air they live by : but these were but conjectures, and upon further examination feem'd lefs probable. The becieve proceed The fabrick of the wing, as it appears through a moderately magnifying Microscope, seems to be a body confisting of two parts, as is visible in the 4. Figure of the 23. Scheme; and by the 2. Figure of the 26. Scheme; the one is a quilly

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a quilly or finny fubftance, confifting of feveral long, flender and varioufly bended quills or wires, fomething refembling the veins of leaves; thefe are, as 'twere, the finns or quills which ftiffen the whole Area, and keep the other part diftended, which is a very thin transparent skin or membrane variously folded, and platted, but not very regularly, and is befides exceeding thickly bestuck with innumerable small briss, which are onely perceptible by the bigger magnifying Microscope, and not with that neither, but with a very convenient augmentation of skylight projected on the Object with a burning Glass, as I have elsewhere shew'd, or by looking through it against the light.

In fteed of these small hairs, in several other Flies, there are infinite of small Feathers, which cover both the under and upper sides of this thin film as in almost all the forts of Butterss and Moths: and those small parts are not onely shap'd very much like the feathers of Birds, but like those variegated with all the variety of curious bright and vivid colours imaginable; and those feathers are likewise so admirably and delicately rang'd, as to compose very fine flouriss and ornamental paintings, like *Turkie* and *Persian* Carpets, but of far more supassing beauty, as is evident enough to the naked eye, in the painted wings of Butterss, but much more through an ordinary *Microscope*.

Intermingled likewife with these hairs, may be perceived multitudes of little pits, or black spots, in the exended membrane, which seem to be the root of the hairs that grow on the other side; these two bodies seem dispers'd over the whole surface of the wing.

The hairs are best perceiv'd, by looking through it against the light, or, by laying the wing upon a very white piece of Paper, in a convenient light, for thereby every little hair most manifestly appears; a speciment of which you may observe drawn in the fourth Figure of the 23. Scheme, A.B, CD, EF whereof represent some parts of the bones or quills of the wing, each of which you may perceive to be cover'd' over with a multitude of scales, or brifles, the former A B, is the biggeft ftem of all the wing, and may be properly enough call'd the cut-air, it being that which terminates and ftiffens the formost edge of the wing ; the fore-edge of this is arm'd with a multitude of little brifles, or Tenter-hooks, in some standing regular and in order, in others not; all the points of which are directed from the body towards the tip of the wing, nor is this edge onely thus fring'd, but even all the whole edge of the wing is cover'd with a small fringe, confifting of fhort and more flender brifles. This Subject, had I time, would afford excellent matter for the contemplation of the nature of wings and of flying; but, because I may, perhaps, get a more convenient time to profecute that fpeculation, and recollect feveral Observations that I have made of that particular. I shall communation to mid lefs probable. at prefent proceed to

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Observ. XXXIX. Of the Eyes and Head of a Grey drone-Fly, and of several other creatures.

I took a large grey Drone-Fly, that had a large head, but a fmall and flender body in proportion to it, and cutting off its head, I fix'd it with the forepart or face upwards upon my Object Plate (this I made choice of rather then the head of a great blue Fly, becaufe my enquiry being now about the eyes, I found this Fly to have, fift the biggeft clufters of eyes in proportion to his head, of any fmall kind of Fly that I have yet feen, it being fomewhat inclining towards the make of the large Dragon-Flies. Next, becaufe there is a greater variety in the knobs or balls of each clufter, then is of any fmall Fly) Then examining it according to my ufual manner, by varying the degrees of light, and altering its polition to each kinde of light, I drew that reprefentation of it which is delineated in the 24. Scheme, and found thefe things to be as plain and evident, as notable and pleafant.

First, that the greatest part of the face, nay, of the head, was nothing else but two large and protuberant bunches, or prominent parts, ABCDEA, the furface of each of which was all cover'd over, or shap'd into a multitude of small Hemispheres, plac'd in a triagonal order, that being the closest and most compacted, and in that order, rang'd over the whole furface of the eye in very lovely rows, between each of which, as is necessary, were left long and regular trenches, the bottoms of every of which, were perfectly intire and not at all perforated or drill'd through, which I most certainly was affured of, by the regularly reflected Image of certain Objects which I mov'd to and fro between the head and the light. And by examining the Cornea or outward skin, after I had stript it off from the several substript frances that lay within it, and by looking both upon the infide and against the light.

Next, that of those multitudes of Hemispheres, there were observable

two degrees of bignefs, the half of them that were lowermoft, and look'd toward the ground or their own leggs, namely, CDE, CDE being a pretty deal fmaller then the other, namely, ABCE, ABCE, that look'd upward, and fide-ways, or foreright, and backward, which variety I have not found in any other fmall Fly.

Thirdly, that every one of these Hemispheres, as they seem'd to be pretty neer the true shape of a Hemisphere, so was the surface exceeding smooth and regular, reflecting as exact, regular, and perfect an Image of any Object from the surface of them, as a small Ball of Quick-filver of that bigness would do, but nothing neer so vivid, the reflection from these being very languid, much like the reflection from the outside of Water, Glass, Crystal, &c. In so much that in each of these Hemispheres, I have been able to discover a Land-scape of those things which lay before my window,

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window, one thing of which was a large Tree, whofe trunk and top I could plainly difcover, as I could alfo the parts of my window, and my hand and fingers, if I held it between the Window and the Object; a fmall draught of nineteen of which, as they appear'd in the bigger Magnifying-glafs to reflect the Image of the two windows of my Chamber, are delineated in the third Figure of the 23. Scheme.

Fourthly, that these rows were so dispos'd, that there was no quarter visible from his head that there was not some of these Hemispheres directed against; so that a Fly may be truly faid to have an eye every way, and to be really circumspect. And it was further observable, that that way where the trunk of his body did hinder his prospect backward, these protuberances were elevated, as it were, above the plain of his shoulders and back, so that he was able to see backwards also over his back.

Fifthly, in living Flies, I have observ'd, that when any small mote or dust, which flies up and down the air, chances to light upon any part of these knobs, as it is fure to flick firmly to it and not fall, though through the Microscope it appears like a large stone or stick (which one would admire, efpecially fince it is no ways probable that there is any wet or glutinous matter upon these Hemispheres, but I hope I shall render the reason in another place) fo the Fly prefently makes use of his two fore-feet in fread of eye-lids, with which, as with two Brooms or Brushes, they being all bestuck with Brifles, he often sweeps or brushes off what ever hinders the prospect of any of his Hemispheres, and then, to free his leggs from that dirt, he rubs them one against another, the pointed Brisles or Tenters of which looking both one way, the rubbing of them to and fro one against another, does cleanse them in the same manner as I have observ'd those that Card Wool, to cleanse their Cards, by placing their Cards, so as the teeth of both look the fame way, and then rubbing them one against another. In the very fame manner do they brush and cleanse their bodies and wings, as I shall by and by shew ; other creatures have other contrivances for the cleanfing and cleering their eyes.

Sixthly, that the number of the Pearls or Hemispheres in the clusters of this Fly, was neer 14000. which I judged by numbering certain rows of them feveral ways, and cafting up the whole content, accounting each clufter to contain about feven thousand Pearls, three thousand of which were of a cize, and confequently the rows not fo thick, and the foure thousand I accounted to be the number of the smaller Pearls next the feet and probofcis. Other Animals I observed to have yet a greater number, as the Dragon-Fly or Adderbolt : And others to have a much lefs company, as an Ant, &c. and feveral other small Flies and Infects. seventhly, that the order of these eies or Hemispheres was altogether curious and admirable, they being plac'd inall kind of Flies, and aerial animals, in a most curious and regular ordination of triangular rows, in which order they are rang'd the neerest together that possibly they can, and confequently leave the least pits or trenches between them. But in shrimps, Crawfishes, Lobsters, and fuch kinds of Crustaceous water Animals, I have yet yet observ other at ri furfaces ; their eyes want. So in Nature, th confider d that wil, to Wisdom a Upor

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yet obferv'd them rang'd in a quadrangular order, the rows cutting each other at right angles, which as it admits of a lefs number of Pearls in equal furfaces; fo have those creatures a recompence made them, by having their eyes a little movable in their heads, which the other altogether want. So infinitely wife and provident do we find all the Dispensations in Nature, that certainly *Epicurus*, and his followers, must very little have confider'd them, who afcrib'd those things to the production of chances, that wil, to a more attentive confiderer, appear the products of the highest Wisdom and Providence.

Upon the Anatomy or Diffection of the Head, I observ'd these particulars:

First, that this outward skin, like the Cornea of the eyes of the greater Animals, was both flexible and transparent, and seem'd, through the Microscope, perfectly to refemble the very substance of the Cornea of a man's eye; for having cut out the cluster, and remov'd the dark and mucous stuff that is subjacent to it, I could see it transparent like a thin piece of skin, having as many cavities in the infide of it, and rang'd in the same order as it had protaberances on the outside, and this propriety, I found the fame in all the Animals that had it, whether Flies or Shell-Fish.

Secondly, I found that all Animals that I have observ'd with those kind of eyes, have within this *Cornea*, a certain cleer liquor or juice, though in a very little quantity, and,

I observ'd thirdly, that within that cleer liquor, they had a kind of dark *mucous* lining, which was all spread round within the cavity of the cluster, and seem'd very neer adjoining to it, the colour of which, in some Flies, was grey; in others, black; in others red; in others, of a mix'd colour; in others, spotted; and that the whole clusters, when look'd on whil'st the Animal was living, or but newly kill'd, appear'd of the same colour that this ceat (as I may so call it) appear'd of, when that outward skin, or *Cornea*, was remov'd.

Fourthly, that the reft of the capacity of the clufters was in fome, as in Dragon Flies, O.c. hollow, or empty; in others fill'd with fome kind of fubstance; in blue Flies, with a reddifh musculous substance, with fibres tending from the center or bottom outwards; and divers other, with various and differing kinds of substances. That this curious contrivance is the organ of fight to all those various Crustaceous Animals, which are furnish'd with it, I think we need not doubt, if we confider but the feveral congruities it has with the eyes of greater creatures. As first, that it is furnish'd with a Cornea, with a transparent humour, and with a uvea or retina, that the Figure of each of the fmall Hemispheres are very spherical, exactly polifi'd, and most vivid, lively and plump, when the Animal is living, as in greater Animals, and in like manner dull, flaccid, and irregular, or fhrunk, when the Animal is dead. Next, that those creatures that are furnish'd with it, have no other organs that have any refemblance to the known eyes of other creatures. Thirdly, Bb

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Thirdly, that those which they call the eyes of Crabs, Lobsters, Shrimps, and the like, and are really fo, are Hemispher'd, almost in the same manner as these of Flies are. And that they really are so, I have very often try'd, by cutting off these little movable knobs, and putting the creature again into the water, that it would fivim to and fro, and move up and down as well as before, but would often hit it felf against the rocks or ftones; and though I put my hand just before its head, it would not at all start or fly back till I touch'd it, whereas whil'st those were remaining, it would ftart back, and avoid my hand or a ftick at a good diftance before it touch'd it. And if in crustaceous Sea-animals, then it seems very probable alfo, that these knobs are the eyes in crustaceous Infects, which are alfo of the fame kind, onely in a higher and more active Element; this the conformity or congruity of many other parts common to either of them, will ftrongly argue, their crustaceous armour, their number of leggs, which are fix, befide the two great claws, which answer to the wings in Infects; and in all kind of Spiders, as also in many other Infects that want wings. we shall find the compleat number of them, and not onely the number, but the very shape, figure, joints, and claws of Lobsters and Crabs, as is evident in Scorpions and Spiders, as is visible in the fecond Figure of the 31. Scheme, and in the little Mite-worm, which I call a Land-crab, defcrib'd in the fecond Figure of the 33. Scheme, but in their manner of generation being oviparous, O.c. And it were very worthy observation, whether there be not fome kinds of transformation and metamorphofis in the feveral states of crustaceous water-animals, as there is in several forts of Infects; for if fuch could be met with, the progress of the variations would be much more confpicuous in those larger Animals, then they can be in any kind of Infects our colder Climate affords.

These being their eyes, it affords us a very pretty Speculation to contemplate their manner of vision, which, as it is very differing from that of *biocular* Animals, so is it not less admirable.

That each of these Pearls or Hemispheres is a perfect eye, I think we need not doubt, if we confider onely the outfide or figure of any one of them, for they being each of them cover'd with a transparent protuberant Cornea, and containing a liquor within them, refembling the watry or glaffie humours of the eye, must necessarily refract all the parallel Rays that fall on them out of the air, into a point not farr distant within them, where (in all probability) the Retina of the eye is placed, and that opacous, dark, and mucous inward coat that (I formerly fhew'd) I found to fubtend the concave part of the clufter is very likely to be that tunicle or coat, it appearing through the Microscope to be plac'd a little more than a Diameter of those Pearls below or within the tunica cornea. And if so, then is there in all probability, a little Picture or Image of the objects without, painted or made at the bottom of the Retina against every one of those Pearls, so that there are as many impressions on the Retina or opacous skin, as there are Pearls or Hemispheres on the cluster. But because it is impossible for any protuberant surface what soever, whether spharial or other, so to refract the Rays that come from farr remote lateral

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lateral points of any Object as to collect them again, and unite them each in a diftinct point, and that onely those Rays which come from some point that lies in the Axis of the Figure produc'd, are fo accurately refracted to one and the fame point again, and that the lateral Rays, thefurther they are remov'd, the more imperfect is their refracted confluence; It follows therefore, that onely the Picture of those parts of the external objects that lie in, or neer, the Axis of each Hemilphere, 'are difcernably painted or made on the Retina of each Hemisphere, and that therefore each of them can diffinctly fensate or fee onely those parts which are very neer perpendicularly opposid to it, or lie in or neer its optick Axis. Now, though there may be by each of these eye-pearls, a representation to the Animal of a whole Hemisphere in the fame manner as in a man's eye there is a ricture or fenfation in the Retina of all the objects lying almost in an Hemisphere; yet, as in a man's eye also, there are but some very few points which living in, or neer, the optick Axis are diffinctly difcern'd: So there may be multitudes of Pictures made of an Object in the feveral Pearls, and yet but one, or fome very few that are diffinct; The representation of any object that is made in any other Pearl, but that which is directly, or very neer directly, oppos'd, being altogether confus'd and unable to produce a diftinct vision. II be note exceedin

So that we fee, that though it has pleas'd the All-wife Creator, to indue this creature with fuch multitudes of eyes, yet has he not indued it with the faculty of feeing more then another creature; for whereas this cannot move his head, at leaft can move itvery little, without moving his whole body, *biocular* creatures can in an inftant (or *the twinkling of an eye*, which, being very quick, is vulgarly ufed in the fame fignification) move their eyes fo as to direct the optick *Axiv* to any point; nor is it probable, that they are able to fee attentively at one time more then one Phyfical point; for though there be a diftinct Image made in every eye, yet 'tis very likely, that the obferving faculty is only imploy'd about fome one object for which they have moft concern.

Now, as we accurately diffinguish the fite or position of an Object by the motion of the Muscles of the eye requisite to put the optick Line in a direct polition, and confuledly by the polition of the imperfect Picture of the object at the bottom of the eye; fo are these crustaceous creatures able to judge confusedly of the polition of objects by the Picture or impreffion made at the bottom of the oppofite Pearl, and diffinctly by the removal of the attentive or observing faculty, from one Pearl to another, but what this faculty is, as it requires another place, fo a much deeper fpeculation. Now, becaufeit were impoffible, even with this multitude of eyeballs, to fee any object diffinct (for as I hinted before, onely those parts that lay in or veryneer, the optick Lines could be fo) the Infinitely wife Creator has not left the creature without a power of moving the head a little in Aerial crustaceous animals, and the very eyes also in crustaceous Sea-animals; fo that by these means they are inabled to direct some optick line or other against any object, and by that means they have the visive faculty as compleat as any Animal that can move its eyes. bro dropt light to wor a said Distances Bb2

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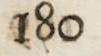
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Distances of Objects also, 'tis very likely they distinguish, partly by the confonant impressions made in some two convenient Pearls, one in each clufter; for, according as those congruous impressions affect, two Pearls neerer approach'd to each other, the neerer is the Object, and the farther they are diftant, the more diftant is the Object: partly alfo by the alteration of each Pearl, requifite to make the Senfation or Picture perfect ; for 'tis impossible that the Pictures of two Objects, variously distant, can be perfectly painted, or made on the fame Retina or bottom of the eye not altered, as will be very evident to any one that shall attentively confider the nature of refraction. Now, whether this alteration may be in the Figure of the Cornea, in the motion of access or recess of the Retina towards the Cornea, or in the alteration of a crustaline humour, if fuch there be, I pretend not to determine; though I think we need not doubt, but that there may be as much curiofity of contrivance and ftructure in every one of these Pearls, as in the eye of a Whale or Elephant, and the almighty's Fiat could as eafily caufe the existence of the one as the other; and as one day and a thousand years are the same with him, so may one eye and ten thousand.

This we may be fure of, that the filaments or fenfative parts of the *Retina* muft be moft exceedingly curious and minute, fince the whole Picture it felf is fuch; what muft needs the component parts be of that *Retina* which diffinguifhes the part of an object's Picture that muft be many millions of millions lefs then that in a man's eye? And how exceeding curious and fubtile muft the component parts of the *medium* that conveys light be, when we find the inftrument made for its reception or refraction to be fo exceedingly fmall? we may, I think, from this fpeculation be fufficiently difcouraged from hoping to difcover by any optick or other inftrument the determinate bulk of the parts of the *medium* that conveys the pulfe of light, fince we find that there is not lefs accuratenes flewn in the Figure and polifh of those exceedingly minute lenticular furfaces, then in those more large and confpicuous furfaces of our own eyes. And yet can I not doubt, but that there is a determinate bulk of those parts, fince I find them unable to enter between the parts of

Mercury, which being in motion, must necessarily have pores, as I shall elsewhere shew, and here pass by, as being a digression.

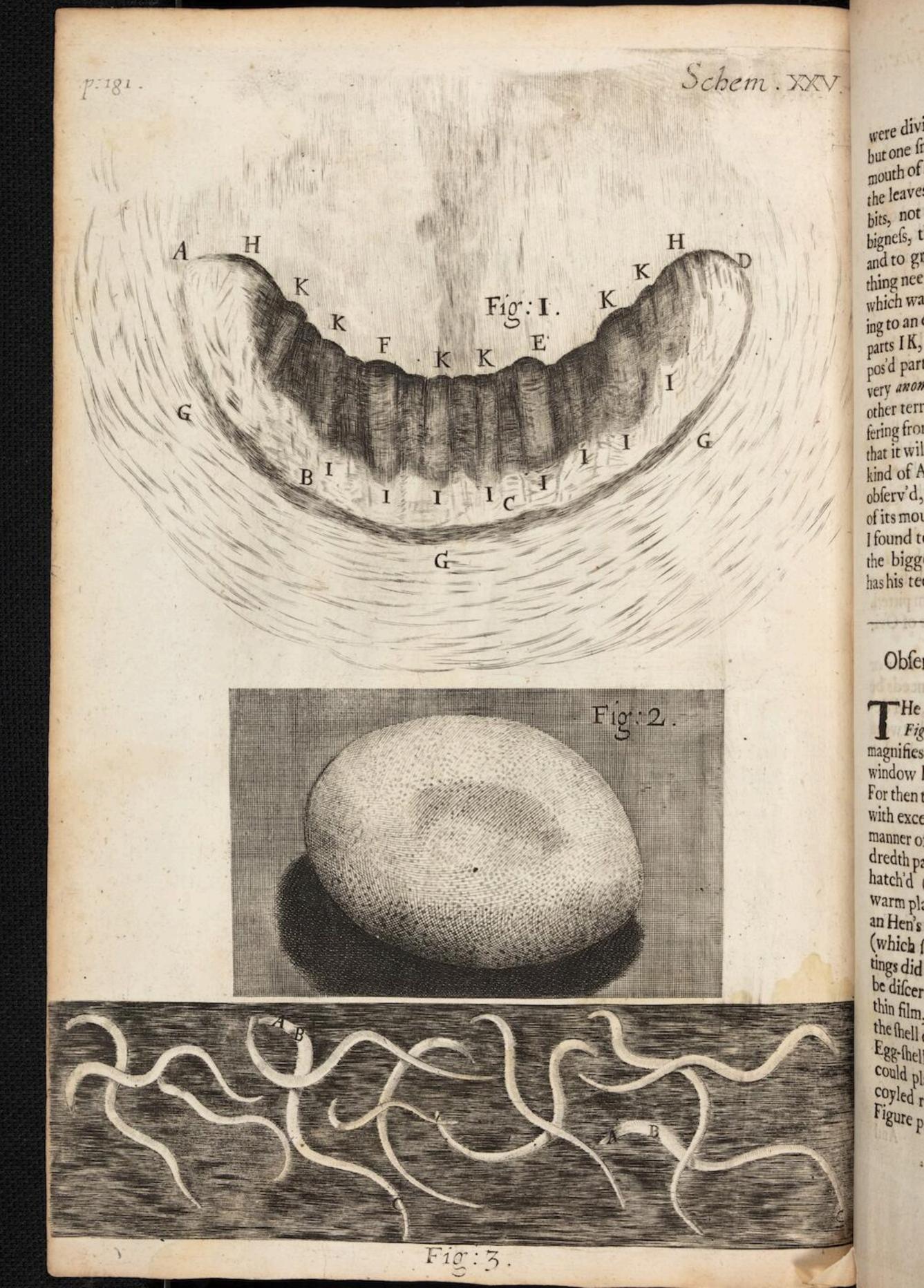
As concerning the horns FF, the feelers or fmellers, GG, the Probascis HH, and I, the hairs and brilles, KK, I shall indeavour to deferibe in the 42. Observation.

Observ. X L. Of the Teeth of a Snail.

Have little more to add of the Teeth of a Snail, befides the Picture of it, which is reprefented in the first Figure of the 25. Scheme, fave that his bended body, ABCDEF, which feem'd fashioned very much like a row of small teeth, orderly plac'd in the Gums, and looks as if it were by by one in two to and y alfo icture ioufly ottom attentation of the our, if d not ftruohant, one as him, fo

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were divided into feveral smaller and greater black teeth, was nothing but one fmall bended hard bone, which was plac'd in the upper jaw of the mouth of a Houfe-Snail, with which I obferv'd this very Snail to feed on the leaves of a Rofe-tree, and to bite out pretty large and half round bits, not unlike the Figure of a (C) nor very much differing from it in bigness, the upper part ABCD of this bone, I found to be much whiter, and to grow out of the upper chap of the Snail G G G, and not to be any thing neer fo much creas'd as the lower and blacker part of it HIIHKKH which was exactly fhap'd like teeth, the bone growing thinner, or tapering to an edge towards K K K. It feem'd to have nine teeth, or prominent parts IK, IK, IF, Oc. which were join'd together by the thinner interpos'd parts of the bone. The Animal to which these teeth belong, is a very anomalous creature, and feems of a kind quite distinct from any other terreftrial Animal or Infect, the Anatomy whereof exceedingly differing from what has been hitherto given of it I should have inferted, but that it will be more proper in another place. I have never met with any kind of Animal whole teeth are all join'd in one, fave onely that I lately observ'd, that all the teeth of a Rhinocerot, which grow on either fide of its mouth, are join'd into one large bone, the weight of one of which I found to be neer eleven pound Haverdupois. So that it feems one of the biggeft fort of terreftrial Animals, as well as one of the fmalleft, has his teeth thus fhap'd. fubiliance as the Silk-worms Eggs, but could not perceive thempitte

Observ. XLI. Of the Eggs of Silk-worms, and other Infects.

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"He Eggs of Silk-worms (one of which I have deferib'd in the fecond Figure of 25. Scheme) afford a pretty Object for a Microfcope that magnifies very much, especially if it be bright weather, and the light of a window be caft or collected on it by a deep Convex-glass, or Water-ball. For then the whole furface of the Shell may be perceiv'd all cover'd over with exceeding fmall pits or cavities with interposed edges, almost in the manner of the furface of a Poppy-feed, but that these holes are not an hundredth part fcarce of their bignefs; the Shell, when the young ones were hatch'd (which I found an eafie thing to do, if the Eggs were kept in a warm place) appear'd no thicker in proportion to its bulk, then that of an Hen's or Goos's Egg is to its bulk, and all the Shell appear'd very white (which feem'd to proceed from its transparency) whence all those pittings did almost vanish, so that they could not, without much difficulty, be difcern'd, the infide of the Shell feem'd to be lin'd alfo with a kind of thin film, not unlike (keeping the proportion to its Shell) that with which the shell of an Hen-egg is lin'd ; and the shell it felf feem'd like common Egg-shells, very brittle, and crack'd. In divers other of these Eggs I could plainly enough, through the shell, perceive the small Infect lie coyled round the edges of the shell. The shape of the Egg it felf, the Figure pretty well represents (though by default of the Graver it does not

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MICROGRAPHIA.

not appear fo rounded, and lying above the Paper, as it were, as it ought to do) that is, it was for the most part pretty oval end-ways, somewhat like an Egg, but the other way it was a little flatted on two opposite fides. Divers of these Eggs, as is common to most others, I found to be barren, or addle, for they never afforded any young ones. And those I ufually found much whiter then the other that were prolifick. The Eggs of other kinds of Oviparous Infects I have found to be perfectly round every way, like fo many Globules, of this fort I have observ'd fome forts of Spiders Eggs; and chancing the last Summer to inclose a very large and curioufly painted Butterfly in a Box, intending to examine its gaudery with my Microscope, I found within a day or two after I inclos'd her, almost all the inner surface of the Box cover'd over with an infinite of exactly round Eggs, which were fluck very fast to the fides of it, and in fo exactly regular and close an order, that made me call to mind my Hypothesis, which I had formerly thought on for the making out of all the regular Figures of Salt, which I have elfewhere hinted ; for here I found all of them rang'd into a most exact triagonal order, much after the manner as the Hemispheres are place on the eye of a Fly; all which Eggs I found after a little time to be hatch'd, and out of them to come a multitude of small Worms, very much refembling young Silk-worms, leaving all their thin hollow shells behind them, sticking on the Box in their triagonal posture; these I found with the Microscope to have much fuch a fubstance as the Silk-worms Eggs, but could not perceive them pitted. And indeed, there is as great a variety in the shape of the Eggs of Oviparous Infects as among those of Birds.

Of these Eggs, a large and lusty Fly will at one time lay neer four or five hundred, so that the increase of these kind of Insects must needs be very prodigious, were they not prey'd on by multitudes of Birds, and destroy'd by Frosts and Rains; and hence 'tis those hotter Climates between the *Tropicks* are infested with such multitudes of Locusts, and such other Vermine.

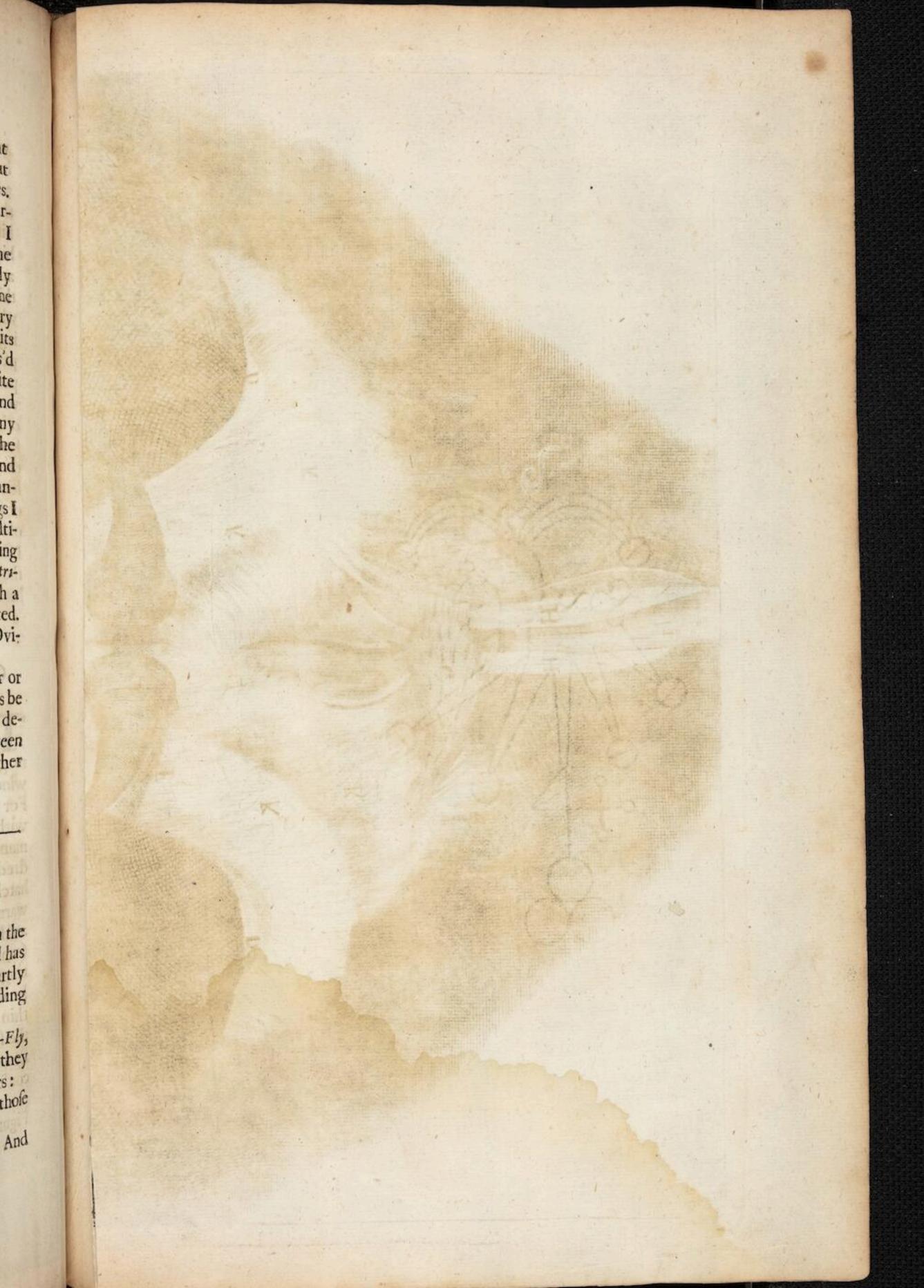
Observ. XLII. Of a blue Fly.

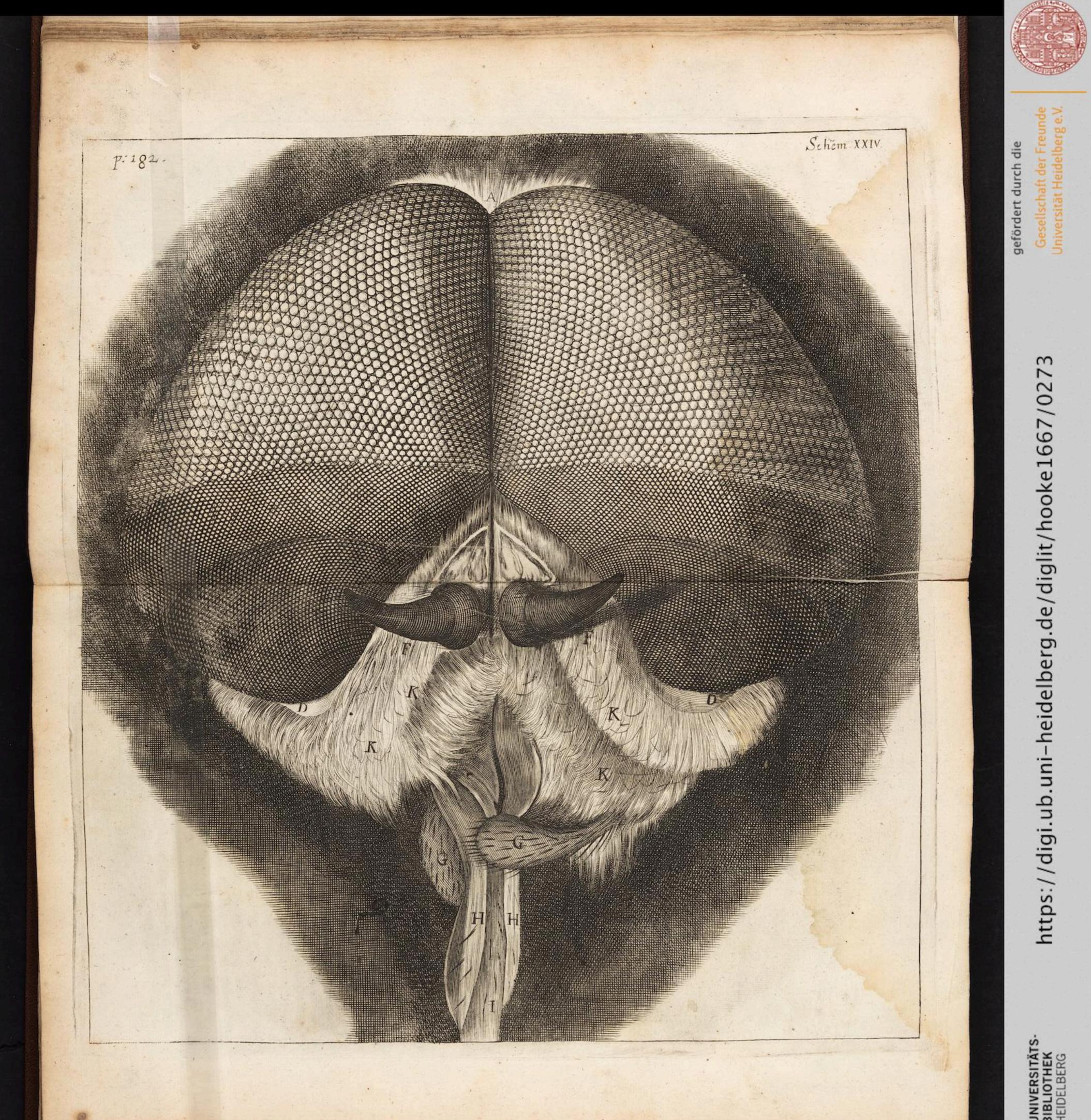
This kind of Fly, whereof a *Microfcopical* Picture is delineated in the first *Figure* of the 26. *scheme*, is a very beautifull creature, and has many things about it very notable ; divers of which I have already partly describ'd, namely, the feet, wings, eyes, and head, in the preceding Observations.

And though the head before defcrib'd be that of a grey Drone-Fly, for the main it is very agreeable to this. The things wherein they most, will be easily enough found by the following particulars: the clusters of eyes of this Fly, are very much smaller then those m-Fly, in proportion to the head.

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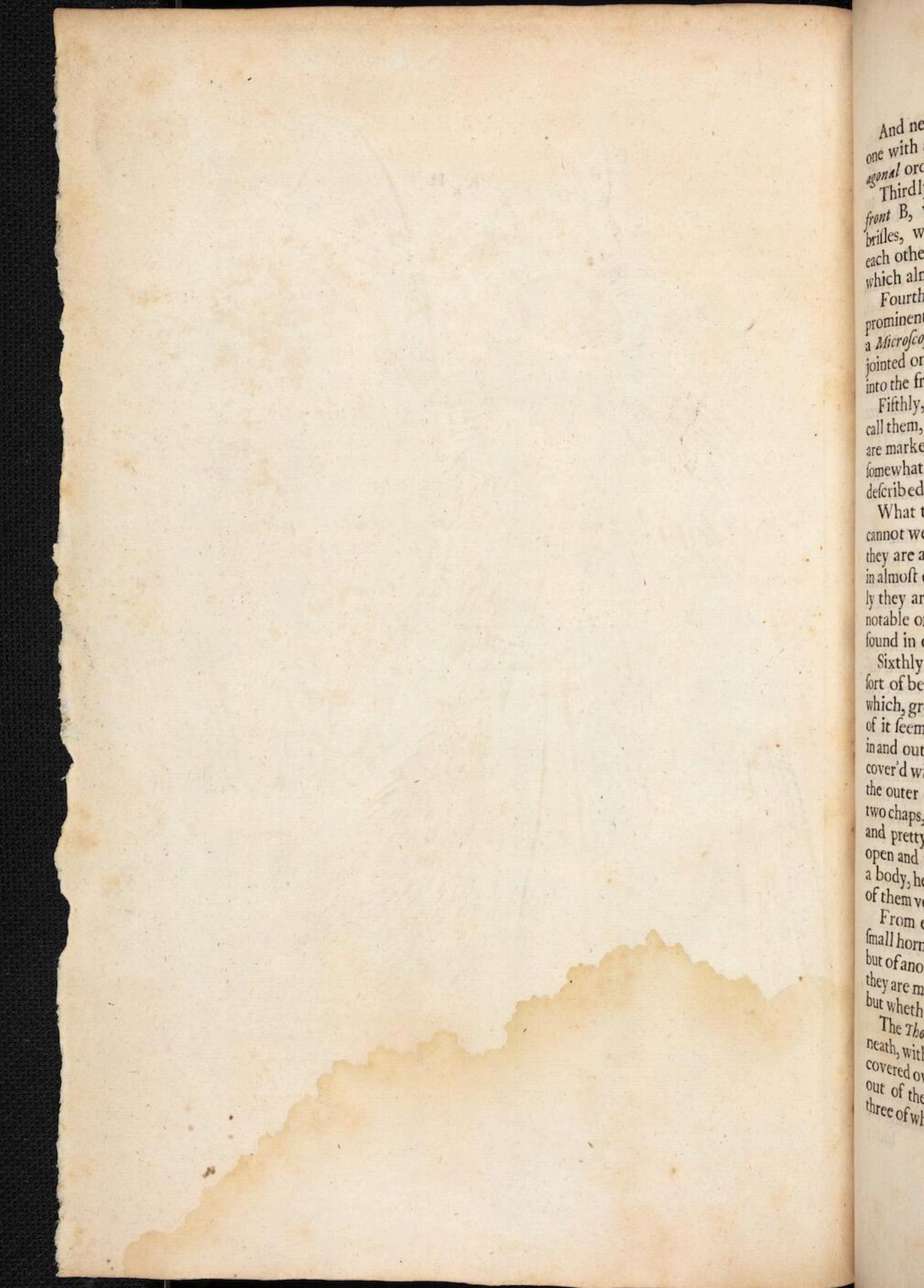
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And next, all the eyes of each cluster seem'd much of the same bigness one with another, not differing as the other, but rang'd in the same triagonal order.

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Thirdly, between these two clusters, there was a scaly prominent front B, which was arm'd and adorn'd with large tapering sharp black briss, which growing out in rows on either side, were so bent toward each other neer the top, as to make a kind of arched arbour of Briss, which almost cover'd the former front.

Fourthly, at the end of this Arch, about the middle of the face, on a prominent part C, grew two fmall oblong bodies, DD, which through a *Microfcope* look'd not unlike the Pendants in Lillies, these feem'd to be jointed on to two fmall parts at C, each of which feem'd again jointed into the front.

Fifthly, out of the upper part and outfides of these horns (as I may call them, from the Figure they are of, in the 24. *Scheme*, where they are marked with FF) there grows a single feather, or brushy Brisse, EE, somewhat of the same kind with the tusts of a Gnat, which I have before described.

What the use of these kind of horned and tusted bodies should be, I cannot well imagine, unless they ferve for smelling or hearing, though how they are adapted for either, it seems very difficult to describe they are in almost every feveral kind of Flies of so various a shape; though certainly they are some very effectial part of the head, and have some very notable office as fign'd them by Nature, since in all Infects they are to be found in one or other form.

Sixthly, at the under part of the face FF, were feveral of the former fort of bended Brifles; and below all, the mouth, out of the middle of which, grew the proboscis G H I, which, by means of feveral joints, whereof it feem'd to confift, the Fly was able to move to and fro, and thruft it in and out as it pleas'd; the end of this hollow body (which was all over cover'd with fmall fhort hairs or brifles) was, as 'twere, bent at H, and the outer or formost fide of the bended part HI, flit, as it were, into two chaps, HI, HI, all the outfide of which where cover'd with hairs, and pretty large brifles; these he could, like two chaps, very readily open and fhut, and when he feem'd to fuck any thing from the furface of a body, he would fpread abroad those chaps, and apply the hollow part of them very close to it. From either fide of the Probofcis, within the mouth, grew two other fmall horns, or fingers, K K, which were hairy, but fmall in this Figure ; but of another fhape, and bigger in proportion, in the 24. Scheme, where they are marked with G G, which two indeed feem'd a kind of fmellers, but whether fo or not, I cannot politively determine. The Thorax or middle part of this Fly, was cas'd, both above and beneath, with a very firm cruft of armour, the upper part more round, and covered over with long conical brifles, all whofe ends pointed backwards; out of the hinder and under part of this grew out in a clufter fix leggs, three of which are apparent in the Figure, the other three were hid by the body

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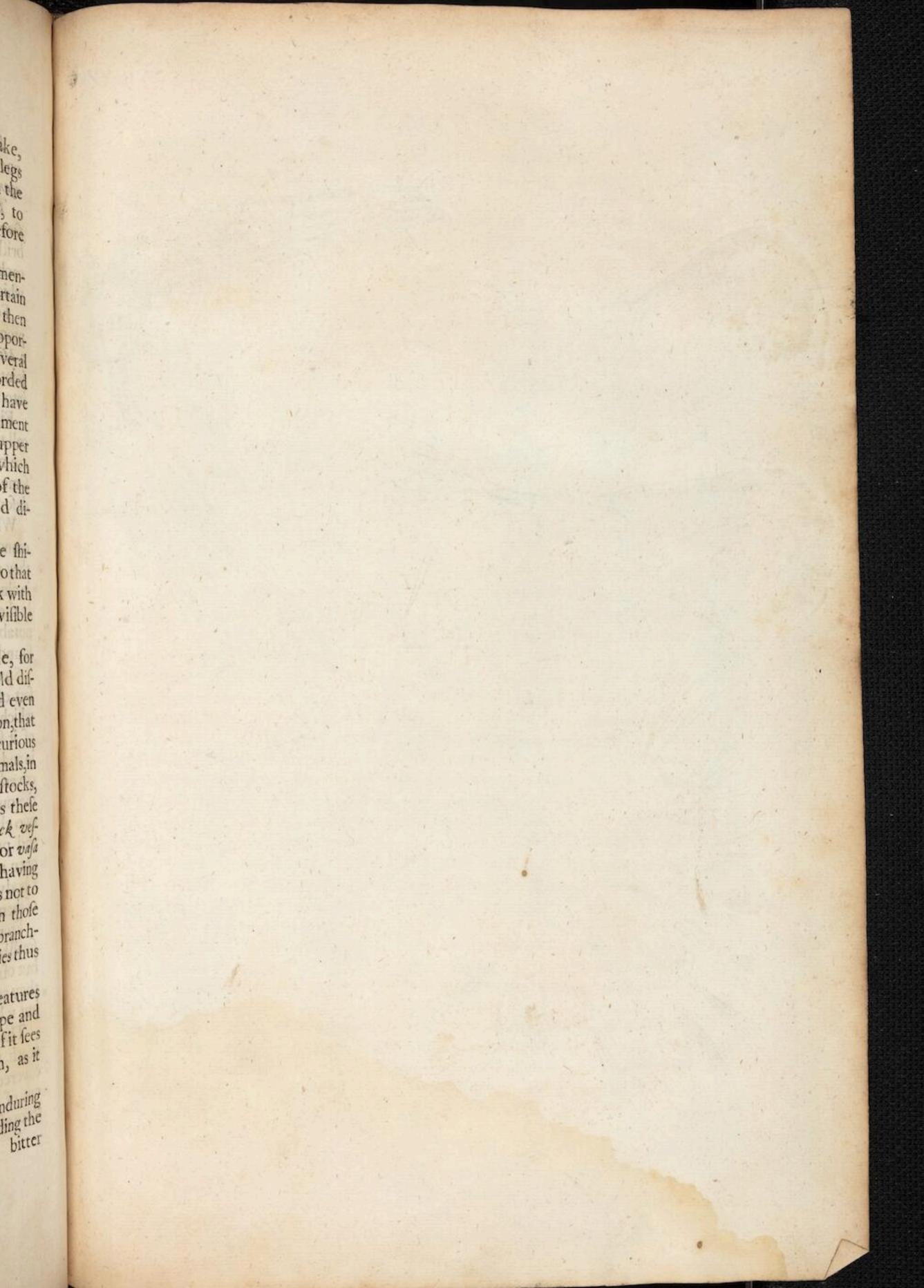
body plac'd in that pofture. The leggs were all much of the fame make, being all of them cover'd with a ftrong hairy fcale or fhel, juft like the legs of a Crabb or Lobster, and the contrivance of the joints feem'd much the fame; each legg feem'd made up of eight parts, 1, 2, 3, 4, 5, 6, 7, 8, to the eighth or last of which, grew the foles and claws, defcribed before in the 38. Observation.

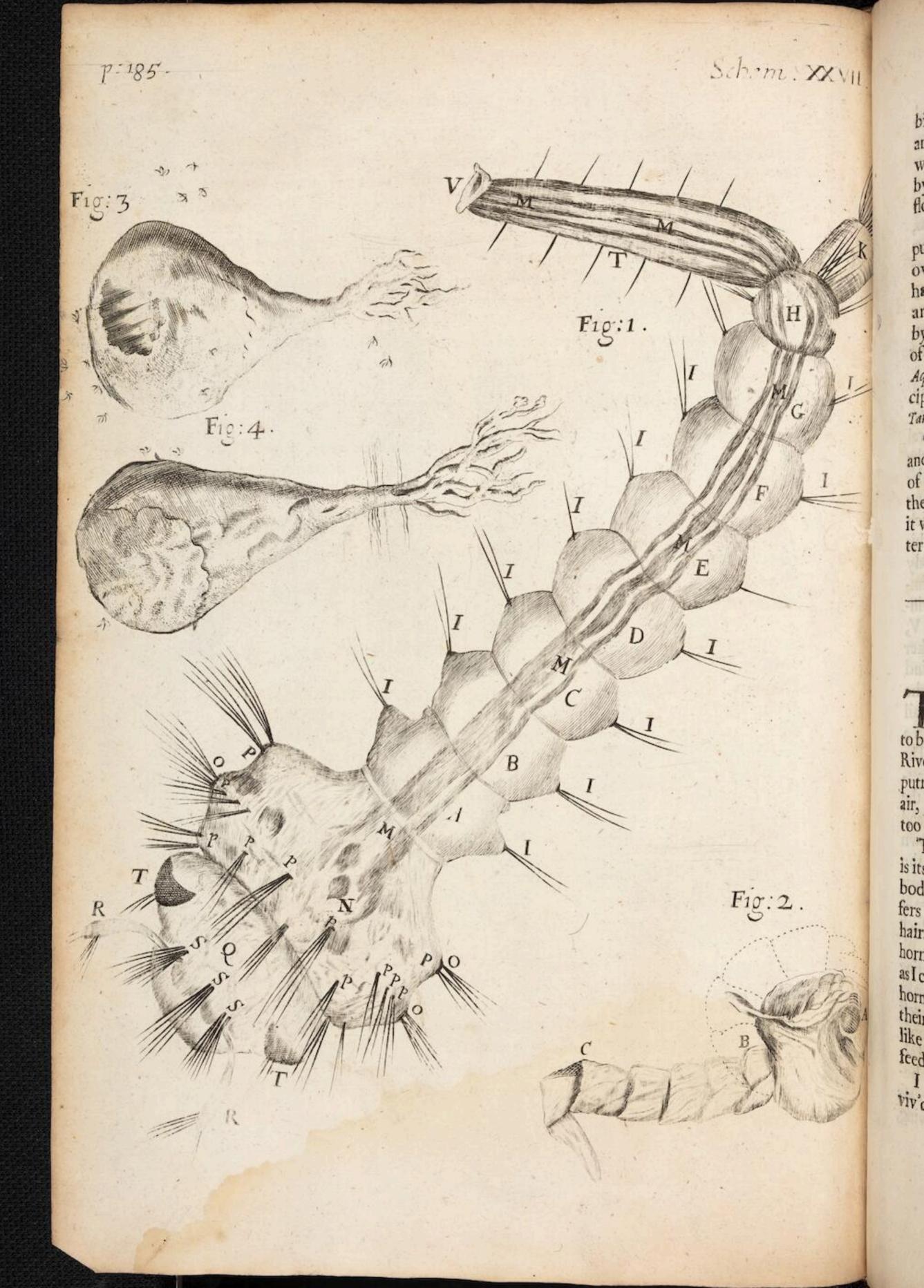
Out of the upper part of this trunck grew the two wings, which I mention d in the 38. Observation, confisting of a film, extended on certain small stiff wires or bones: these in a blue Fly, were much longer then the body, but in other kind of Flies they are of very differing proportions to the body. These films, in many Flies, were so thin, that, like several other plated bodies (mention'd in the ninth Observation) they afforded all varieties of fantastical or transfert colours (the reason of which I have here endeavoured to explain) they seem'd to receive their nouriss from the stalks or wires, which seem'd to be hollow, and neer the upper part of the wing LL several of them seem'd jointed, the set of which will sufficiently appear by the black lines in the second Figure of the 26. scheme, which is a delineation of one of those wings expanded directly to the eyes.

All the hinder part of its body is cover'd with a most curious blue shining armour, looking exactly like a polish'd piece of steel brought to that blue colour by annealing, all which armour is very thick bestuck with abundance of tapering brisles, such as grow on its back, as is visible enough by the Figure.

Nor was the infide of this creature lefs beautifull then its outfide, for cutting off a part of the belly, and then viewing it, to fee if I could difcover any Veffels, fuch as are to be found in a greater Animals, and even in Snails exceeding manifestly, I found, much beyond my expectation, that there were abundance of branchings of Milk-white veflels, no lefs curious then the branchings of veins and arteries in bigger terrestrial Animals, in one of which, I found two notable branches, joining their two main ftocks, as it were, into one common ductus; now, to what veins or arteries these Vesiells were analogus, whether to the vena porta, or the meferaick veffells, or the like, or indeed, whether they were veins and arteries, or vafa lactea, properly fo called, I am not hitherto able to determine, having not yet made fufficient enquiry; but in all particulars, there feems not to be any thing lefs of curious contrivance in these Infects, then in those larger terrestrial Animals, for I had never seen any more curious branchings of Veffells, then those I observ'd in two or three of these Flies thus opened. It is a creature active and nimble, fo as there are very few creatures like it, whether bigger or smaller, in so much, that it will scape and avoid a fmall body, though coming on it exceeding fwiftly, and if it lees any thing approaching it, which it fears, it prefently squats down, as it were, that it may be the more ready for its rife.

Nor is it lefs hardy in the Winter, then active in the Summer, induring all the Frosts, and furviving till the next Summer, notwithstanding the bitter





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bitter cold of our Climate; nay, this creature will indure to be frozen, and yet not be deftroy'd, for I have taken one of them out of the Snow whereon it has been frozen almost white, with the Ice about it, and yet by thawing it gently by the warmth of a fire, it has quickly reviv'd and flown about.

This kind of Fly feems by the fteams or tafte of fermenting and putrifying meat (which it often kifles, as'twere, with its probofcis as it trips over it) to be ftimulated or excited to eject its Eggs or Seed on it, perhaps, from the fame reason as Dogs, Cats, and many other brute creatures are excited to their particular lufts, by the fmell of their females, when by Nature prepared for generation; the males feeming by those kind of fmells, or other incitations, to be as much neceffitated thereto, as Aqua Regis strongly impregnated with a folution of Gold, is forced to precipitate it by the affusion of spirit of Urine, or a folution of salt of Tartar.

One of these put in spirit of Wine, was very quickly seemingly kill'd, and both its eys and mouth began to look very red, but upon the taking of it out, and fuffering it to lie three or four hours, and heating it with the Sun beams caft through a Burning-glass, it again reviv'd, feeming, as it were, to have been all the intermediate time, but dead drunk, and after certain hours to grow fresh again and sober.

Observ. XLIII. Of the Water-Insect or Gnat.

"His little creature, described in the first Figure of the 27. Scheme? Was a fmall fcaled or crufted Animal, which I have often obferv'd to be generated in Rain-water ; I have also observ'd it both in Pond and River-water. It is suppos'd by some, to deduce its first original from the putrifaction of Rain-water, in which, if it have flood any time open to the air, you shall feldom miss,all the Summer long, of store of them frisking too and fro. 'Tisa creature, wholly differing in fhape from any I ever observ'd; nor is its motion less strange: It has a very large head, in proportion to its body, all covered with a shell, like other testaceous Animals, but it differs in this, that it has, up and down feveral parts of it, feveral tufts of hairs, or brifles, plac'd in the order express'd in the Figure; It has two horns, which feem'd almost like the horns of an Oxe, inverted, and, as neer as I could ghefs, were hollow, with tufts of brifles, likewife at the top; thefe horns they could move eafily this or that way, and might, perchance, be their noftrils. It has a pretty large mouth, which feem'd contriv'd much like those of Crabs and Lobsters, by which, I have often observ'd them to teed on water, or some imperceptible nutritive substance in it. I could perceive, through the transparent shell, while the Animal furviv'd, feveral motions in the head, thorax, and belly, very diffinctly, ot

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of differing kinds which I may, perhaps, elfewhere endeavour more accurately to examine, and to fhew of how great benefit the ufe of a *Mierofcope* may be for the difcovery of Nature's courfe in the operations perform'd in Animal bodies, by which we have the opportunity of obferving her through thefe delicate and pellucid teguments of the bodies of Infects acting according to her ufual courfe and way, undifturbed, whereas, when we endeavour to pry into her fecrets by breaking open the doors upon her, and diffecting and mangling creatures whil'ft there is life yet within them, we find her indeed at work, but put into fuch diforder by the violence offer'd, as it may eafily be imagin'd how differing a thing we fhould find, if we could, as we can with a *Microfcope*, in thefe imaller creatures, quietly peep in at the windows, without frighting her out of her ufual by as.

The form of the whole creature, as it appear'd in the Microscope, may, without troubling you with more descriptions, be plainly enough perceiv'd by the scheme, the hinder part or belly confifting of eight feveral jointed parts, namely, A B C D E F G H, of the first Figure, from the midst of each of which, on either fide, isfued out three or four small brifles or hairs, I, I, I, I, I, the tail was divided into two parts of very differing make; one of them, namely, K, having many tufts of hair or brifles, which feem'd to ferve both for the finns and tail, for the Oars and Ruder of this little creature, wherewith it was able, by frifking and bending its body nimbly to and fro, to move himfelf any whither, and to fkull and fteer himfelf as he pleas'd; the other part, L, feem'd to be, as 'twere, the ninth division of his belly, and had many fingle brifles on either fide. From the end V, of which, through the whole belly, there was a kind of Gut of a darker colour, MMM, wherein, by certain Peristaltick motions there was a kind of black substance mov'd upwards and downwards through it from the orbicular part of it, N, (which feem'd the Ventricle, or ftomach) to the tail V, and to back again, which peristaltick motion I have observ'd also in a Loule, a Gnat, and leveral other kinds of transparent body'd Flies. The Thorax or cheft of this creature OOOO, was thick and fhort, and pretty transparent, for through it I could see the white heart (which is the colour also of the bloud in these, and most other Infects) to beat, and feveral other kind of motions. It was beftuck and adorn'd up and down with feveral tufts of brifles, fuch as are pointed out by P, P, P, P, the head Q was likewife bestuck with feveral of those tufts, SSS; it was broad and fhort, had two black eyes, TT, which I could not perceive at all pearl'd, as they afterwards appear'd, and two fmall horns, R R, fuch as I formerly defcrib'd. Both its motion and reft is very ftrange, and pleafant, and differing from those of most other creatures I have observ'd; for, where it ceases from moving its body, the tail of it feeming much lighter then the reft of its body, and a little lighter then the water it fwims in, prefently boys it up to the top of the water, where it hangs fuspended with the head always downward; and like our Antipodes, if they do by a frifk get below that superficies, they presently ascend again unto it, if they cease moving,

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moving, until they tread, as it were, under that fuperficies with their tails; the hanging of these in this posture, put me in mind of a certain creature I have feen in London, that was brought out of America, which would very firmly fuspend it felf by the tail, with the head downwards, and was faid to fleep in that posture, with her young ones in her false belly, which is a Purse, provided by Nature for the production, nutrition, and prefervation of her young ones, which is defcribed by Pife in the 24. Chapter of the fifth Book of his Natural History of Brafil.

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The motion of it was with the tail forwards, drawing its felf backwards, by the frifking to and fro of that tuft which grew out of one of the ftumps of its tail. It had another motion, which was more futable to that of other creatures, and that is, with the head forward; for by the moving of his chaps (if I may to call the parts of his mouth) it was able to move it felf downwards very gently towards the bottom, and did, as 'twere, eat up its way through the water.

But that which was most observable in this creature, was, its Metamorphofis or change; for having kept feveral of these Animals in a Glass of Rain-water, in which they were produc'd, I found, after about a fortnight or three weeks keeping, that feveral of them flew away in Gnats, leaving their hufks behind them in the water floating under the furface, the place where these Animals were wont to refide, whil'ft they were inhabitants of the water : this made me more diligently to watch them, to fee if I could find them at the time of their transformation; and not long after, I observ'd several of them to be changed into an unufual shape, wholly differing from that they were of before, their head and body being grown much bigger and deeper, but not broader, and their belly, or hinder part smaller, and coyl'd, about this great body much of the fashion represented by the prick'd line in the fecond Figure of the 27. Scheme, the head and horns now fwam uppermost, and the whole bulk of the body feem'd to be grown much lighter; for when by my frighting of it, it would by frifking out of its tail (in the manner express'd in the Figure by BC) fink it felf below the furface towards the bottom; the body would more fwiftly re-afcend, then when it was in its former fhape. I still marked its progress from time to time, and found its body still to grow bigger and bigger, Nature, as it were, fitting and accoutring it for the lighter Element, of which it was now going to be an inhabitant; for, by observing one of these with my Microscope, I found the eyes of it to be altogether differing from what they feem'd before, appearing now all over pearl'd or knobb'd, like the eyes of Gnats. as is visible in the lecong Figure by A. At length, I faw part of this creature to fwim above, and part beneath the furface of the water, below which though it would quickly plunge it felf if I by any means frighted it, and prefently re-alcend into its former pollure; after a little longer expectation, I found that the head and body of a Gnat, began to appear and stand cleer above the furface, and by degrees it drew out its leggs, first the two formost, then the other, at length its whole body perfect and entire appear'd out of the hufk (which it left in the water) standing on its leggs upon Cc 2 the

the top of the water, and by degrees it began to move, and after flew about the Glass a perfect Gnat.

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I have been the more particular, and large in the relation of the tranfformation of divers of these little Animals which I observ'd, because I have not found that any Authour has observ'd the like; and because the have not found that any Authour has observ'd the like; and because the thing it felf is so ftrange and heterogeneous from the usual progress of other Animals, that I judge it may not onely be pleasant, but very usefull and necessary towards the compleasing of Natural History.

There is indeed in Pilo, a very odd Hiftory, which this relation may make the more probable; and that is in the 2. Chapter of the 4. Book of his Natural Hiftory of Brafil, where he fays, Porro præter tot documenta fertilitatis circa vegetabilia & sensitiva marina telluris æmula, accidit & illud, quod paucis à Paranambucensi milliaribus piscatoris uncum citra intentionem contingat infigi vadis petrofis, & loco piscis spongia, coralla, aliasque arbusculas marinas capi. Inter hæc inusitatæ formæ prodit spongiosa arbuscula, sesquipedis longitudinis, brevioribus radicibus, lapideis nitens vadis, & rupibus infixa, erigiturque in corpus spongiosum molle oblongum rotundum turbinatum: intus miris cancellis & alveis fabricatum, extus autem tenaci glutine instar Apum propolis undique vestitum, ostio satis patulo & profundo in summitate relicto, sicut ex altera iconum probe depicta videre licet (see the third and fourth Figures of the 27. Scheme.) It a ut Apiarium marinum vere dixeris; primo enim intuitu è Mare ad Terram delatum, vermiculis scatebat cæruleis parvis, qui mox à calore solis in Muscas, vel Apes potius, easq; exignas & nigras transformebantur, circumvolantesque evanescebant, ita ut de eorum mellificatione nihil certi conspici datum fuerit, cum tamen cærosa materia propolis Apumque cella manifeste apparerent, atque ipsa mellis qualiscunque substantia proculdubio urinatoribus patebit, ubi curiosius inquisiverint hæc apiaria, eaque in natali solo & salo diversis temporibus penitius lustrarint.

Which Hiftory contains things fufficiently strange to be confider'd, as whether the hufk were a Plant, growing at the bottom of the Sea before, of it felf, out of whofe putrifaction might be generated these strange kind of Magots; or whether the feed of certain Bees, finking to the bottom, might there naturally form it felf that vegetable hive, and take root; or, whether it might not be placed there by fome diving Fly; or, whether it might not be some peculiar propriety of that Plant, whereby it might ripen or form its vegetable juice into an Animal fubstance; or, whether it may not be of the nature of a Sponge, or rather a Sponge of the nature of this, according to some of those relations and conjectures I formerly made of that body, is a matter very difficult to be determined. But indeed, in this description, the Excellent Pifo has not been sufficiently particular in the fetting down the whole process, as it were to be wish'd : There are indeed very odd progresses in the production of several kinds of Infects, which are not lefs instructive then pleafant, feveral of which, the diligent Goedartius has carefully observ'd and recorded, but among all his Observations, he has none like this, though that of the Hemerobius be somewhat of this kind, which is added as an Appendix by Johannes Mey. I have

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I have, for my own particular, befides feveral of those mention'd by him, observ'd divers other circumstances, perhaps, not much taken notice of, though very common, which do indeed afford us a very coercive argument to admire the goodness and providence of the infinitely wife Creator in his most excellent contrivances and dispensations. I have observ'd, at feveral times of the Summer, that many of the leaves of divers Plants have been spotted, or, as it were scabbed, and looking on the undersides of those of them that have been but a litte irregular, I have perceiv'd them to be fprinkled with divers forts of little Eggs, which letting alone, I have found by degrees to grow bigger, and become little Worms with leggs, but still to keep their former places, and those places of the leaves, of their own accords, to be grown very protuberant upwards, and very hollow, and arched underneath, whereby those young creatures are, as it were, fhelter'd and housed from external injury ; divers leaves I have observ'd to grow and fwell fo farr, as at length perfectly to inclose the Animal, which, by other observations I have made, I ghess to contain it, and become, as it were a womb to it, fo long, till it be fit and prepar'd to be translated into another state, at what time, like (what they fay of) Vipers, they gnaw their way through the womb that bred them; divers of these kinds I have met with upon Goosberry leaves, Rose-tree leaves, Willow leaves, and many other kinds.

There are often to be found upon Rofe-trees and Brier bufhes, little red tufts, which are certain knobs or excrefcencies, growing out from the Rind, or barks of those kinds of Plants, they are cover'd with strange kinds of threads or red hairs, which feel very fost, and look not unpleafantly. In most of these, if it has no hole in it, you shall find certain little Worms, which I suppose to be the causes of their production; for when that Worm has eat its way through, they, having performed what they were design'd by Nature to do, by degrees die and wither away.

Now, the manner of their production, I suppose to be thus; that the Alwife Creator has as well implanted in every creature a faculty of knowing what place is convenient for the hatching, nutrition, and prefervation of their Eggs and of-fprings, whereby they are stimulated and directed to convenient places, which becom, as 'twere the wombs that perform those offices : As he has also suited and adapted a property to those places wherby they grow and inclose those feeds, and having inclosed them, provide a convenient nourifhment for them, but as foon as they have done the office of a womb, they die and wither. The progress of inclosure I have often observ'd in leaves, which in those places where those feeds have been cast, have by degrees fwell'd and inclos'd them, fo perfectly round, as not to leave any perceptible paffage out. From this fame caufe, I suppose that Galls, Oak-apples, and several other productions of that kind, upon the branches and leaves of Trees, have their original; for if you open any of them, when almost ripe, you shall find a little Worm in them. Thus, if you open never fo many dry Galls, you shall find either a hole whereby the Worm has eat its passage out,

out, or if you find no paffage, you may, by breaking or cutting the Gall, find in the middle of it a small cavity, and in it a small body, which does plainly enough yet retain a shape, to manifest it once to have been a Worm, though it dy'd by a too early feparation from the Oak on which it grew, its navel-ftring, as 'twere, being broken off from the leaf or branch by which the Globular body that invelop'd it, received its nourishment from the Oak.

And indeed, if we confider the great care of the Creator in the difpenfations of his providences for the propagation and increase of the race, not onely of all kind of Animals, but even of Vegetables, we cannot chufe but admire and adore him for his Excellencies, but we fhall leave off to admire the creature, or to wonder at the strange kind of acting in feveral Animals, which feem to favour fo much of reafon ; it feeming to me most manifest, that those are but actings according to their structures, and such operations as fuch bodies, fo compos'd, must necessarily, when there are fuch and fuch circumstances concurring, perform : thus, when we find Flies fwarming, about any piece of flesh that does begin a little to ferment; Butterflies about Colworts, and feveral other leaves, which will ferve to hatch and nourifh their young; Gnats, and feveral other Flies about the Waters, and marifhy places, or any other creatures, feeking and placing their Seeds in convenient repolitories, we may, if we attentively confider and examine it, find that there are circumstances fufficient, upon the supposals of the excellent contrivance of their machine, to excite and force them to act after fuch or fuch a manner; those steams that rife from these several places may, perhaps, fet feveral parts of thefe little Animals at work, even as in the contrivance of killing a Fox or Wolf with a Gun, the moving of a string, is the death of the Animal; for the Beast, by moving the flesh that is laid to entrap him, pulls the string which moves the trigger, and that lets go the Cock which on the steel strikes certain sparks of fire which kindle the powder in the pann, and that prefently flies into the barrel, where the powder catching fire rarifies and drives out the bullet which kills the Animal; in all which actions, there is nothing of intention or ratiocination to be afcrib'd either to the Animal or Engine, but all to the ingeniousness of the contriver.

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But to return to the more immediate confideration of our Gnat: We have in it an Inftance, not usual or common, of a very stange amphibious creature, that being a creature that inhabits the Air, does yet produce a creature, that for some time lives in the water as a Fish, though afterward (which is as strange) it becomes an inhabitant of the Air, like its Sire, in the form of a Fly. And this, me thinks, does prompt me to propole certain conjectures, as Queries, having not yet had fufficient opportunity and leifure to answer them my felf from my own Experiments or Obfervations.

And the first is, Whether all those things that we suppose to be bred from corruption and putrifaction, may not be rationally suppos'd to have their origination as natural as these Gnats, who, 'tis very probable, were first dropt into this Water, in the form of Eggs. Those Seeds or Eggs

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Eggs muft certainly be very fmall, which fo fmall a creature as a Gnat yields, and therefore we need not wonder that we find not the Eggs themfelves, fome of the younger of them, which I have obferv'd, having not exceeded a tenth part of the bulk they have afterwards come to; and next,I have obferved fome of those little ones which muft have been generated after the Water was inclosed in the Bottle, and therefore most probably from Eggs, whereas those creatures have been fuppos'd to be bred of the corruption of the Water, there being not formerly known any probable way how they should be generated.

A fecond is, whether these Eggs are immediately dropt into the Water by the Gnats themselves, or, mediately, are brought down by the falling rain; for it feems not very improbable, but that those small feeds of Gnats may (being, perhaps, of so light a nature, and having so great a proportion of surface to so small a bulk of body) be ejected into the Air, and so, perhaps, carried for a good while too and fro in it, till by the drops of Rain it be wash'd out of it.

A third is, whether multitudes of those other little creatures that are found to inhabit the Water for some time, do not, at certain times, take wing and fly into the Air, others dive and hide themselves in the Earth, and so contribute to the increase both of the one and the other Element.

Postfcript.

A good while fince the writing of this Description, I was prefented by Doctor Peter Ball, an ingenious Member of the Royal Society, with a little Paper of Nuts, which he told me was fent him from a Brother of his out of the Countrey, from Mambead in Devonshire, some of them were loofe, having been, as I suppose, broken off, others were still growing fast on upon the fides of a flick, which feem'd by the bark, pliablenefs of it, and by certain ftrings that grew out of it, to be fome piece of the root of a Tree; they were all of them dry'd, and a little shrivell'd, others more round, of a brown colour; their shape was much like a Figg, but very much smaller, some being about the bigness of a Bay-berry others, and the biggeft, of a Hazel-Nut. Some of these that had no hole in them, I carefully opened with my Knife, and found in them a good large round white Maggot, almost as bigg as a small Pea, which seem'd shap'd like other Maggots, but fhorter. I could not find them to move, though I ghefs'd them to be alive, becaufe upon pricking them with a Pinn, there would ifiue out a great deal of white mucous matter, which feem'd to be from a voluntary contraction of their fkin; their hufk or matrix confifted of three Coats, like the barks of Trees, the outermost being more rough and spongie, and the thickeft, the middlemost more close, hard, white, and thin, the innermost very thin, seeming almost like the skin within an Egg's shell. The two outermost had root in the branch or stick, but the innermost had no ftem or process, but was onely a skin that cover'd the cavity of the Nut. All the Nuts that had no holes eaten in them, I found to contain these Maggots, but all that had holes, I found empty, the Maggots, 11

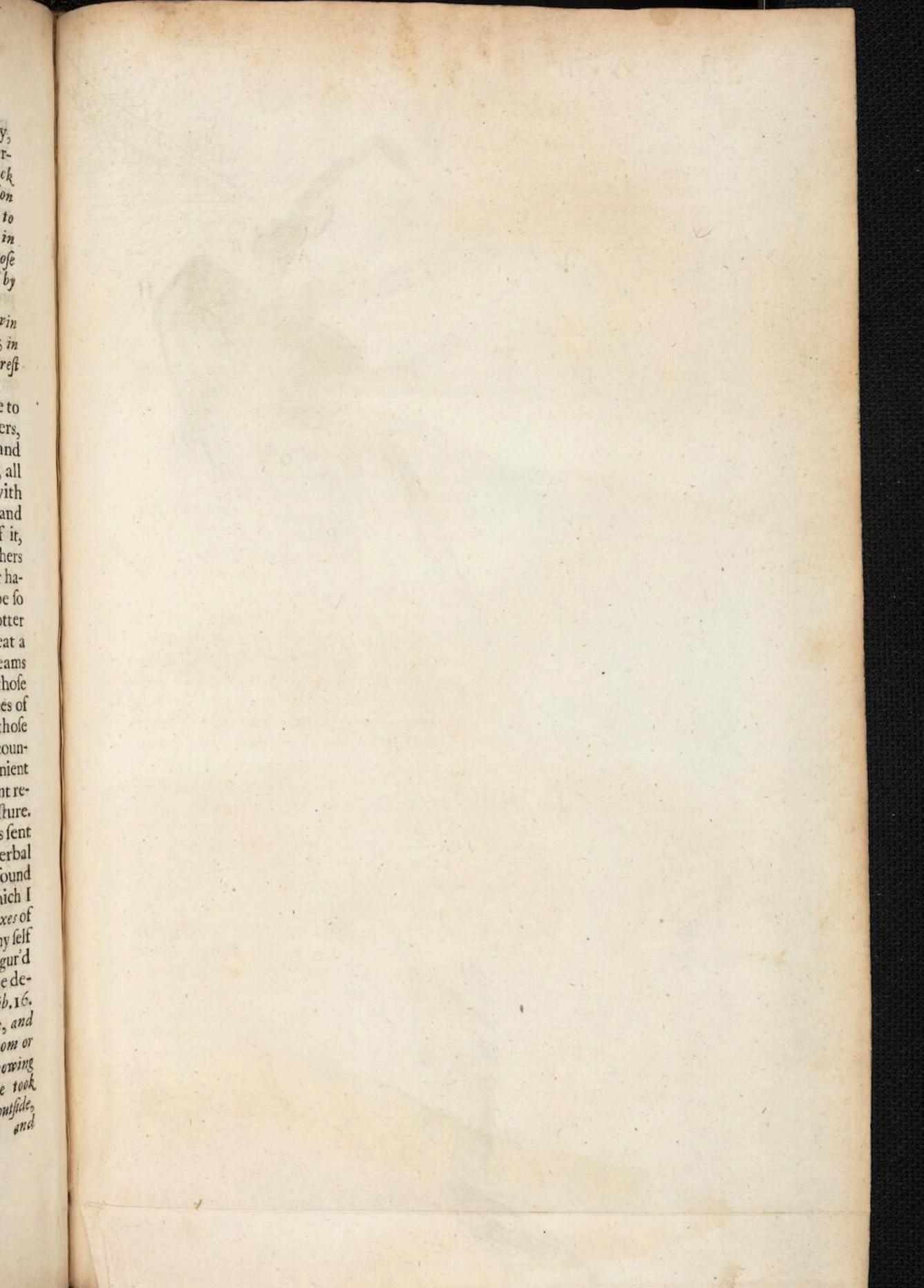
it feems, having eaten their way through, taken wings and flown away, as this following account (which I receiv'd in writing from the fame perfon, as it was fent him by his Brother) manifefts. In a moorifh black Peaty mould, with fome fmall veins of whitifh yellow Sands, upon occasion of digging a hole two or three foot deep, at the head of a Pond or Pool, to fet a Tree in, at that depth, were found, about the end of October 1663. in those very veins of Sand, those Buttons or Nuts, sticking to a little loose stick, that is, not belonging to any live Tree, and some of them also free by themselves.

Four or five of which being then open'd, some were found to contvin live Insects come to perfection, most like to flying Ants, if not the same; in others, Insects, yet imperfect, having but the head and wings form'd, the rest remaining a soft white pulpy substance.

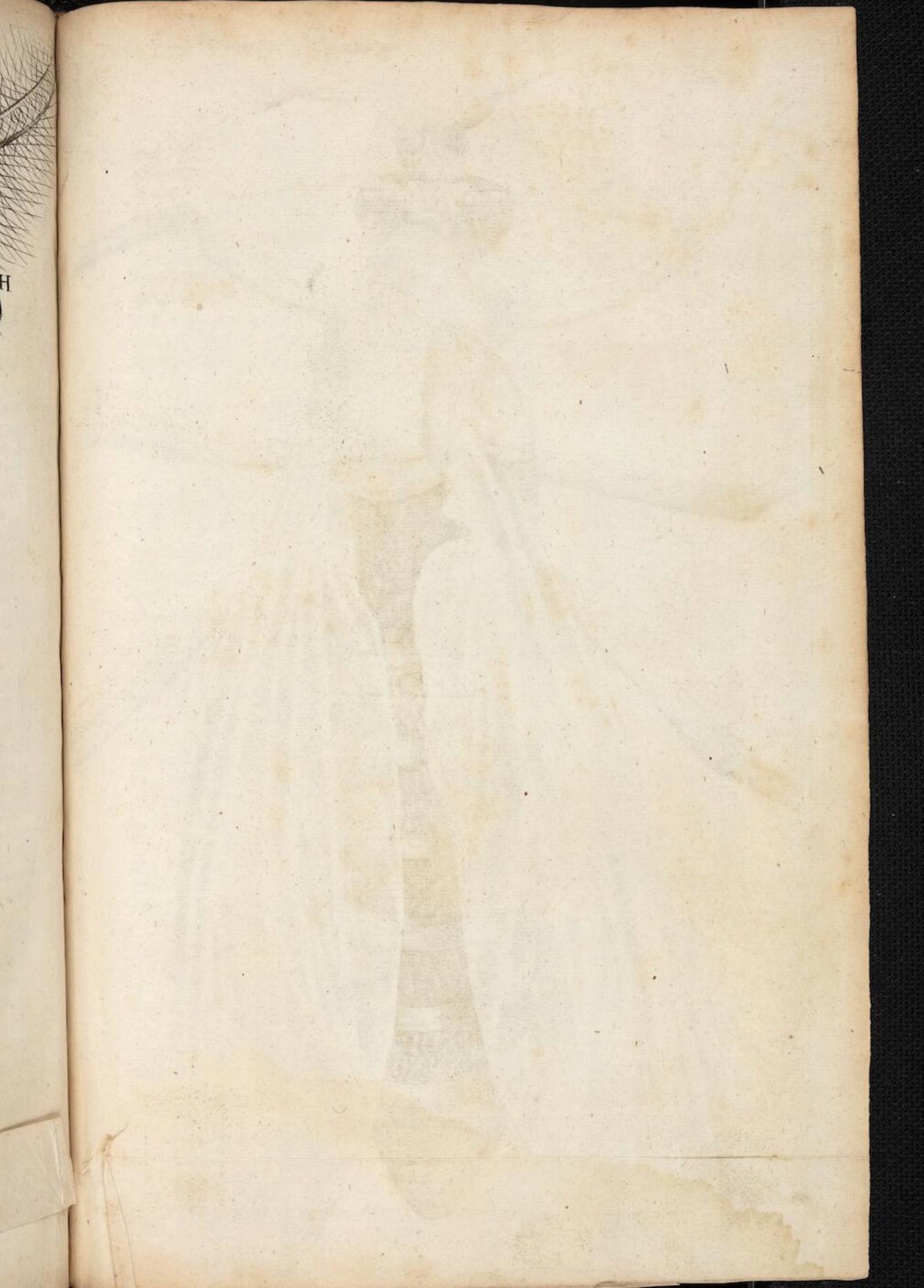
Now, as this furnishes us with one odd History more, very agreeable to what I before hinted, fo I doubt not, but were men diligent observers, they might meet with multitudes of the fame kind, both in the Earth and in the Water, and in the Air, on Trees, Plants, and other Vegetables, all places and things being, as it were animarum plena. And I have often, with wonder and pleafure, in the Spring and Summer-time, look'd clofe to, and diligently on, common Garden mould, and in a very fmall parcel of it, found fuch multitudes and diversities of little reptiles, some in husks, others onely creepers, many wing'd, and ready for the Air ; divers hufks or habitations left behind empty. Now, if the Earth of our cold Climate be fo fertile of animate bodies, what may we think of the fat Earth of hotter Climates? Certainly, the Sun may there, by its activity, caufe as great a parcel of Earth to fly on wings in the Air, as it does of Water in steams and vapours. And what fwarms must we suppose to be sent out of those plentifull inundations of water which are poured down by the fluces of Rain in fuch vaft quantities? So that we need not much wonder at those innumerable clouds of Locusts with which Africa, and other hot countries are fo peftred, fince in those places are found all the convenient caufes of their production, namely, genitors, or Parents, concurrent receptacles or matrixes, and a fufficient degree of natural heat and moisture.

I was going to annex a little draught of the Figure of those Nuts fent out of Devonshire, but chancing to examine Mr. Parkinson's Herbal for something elfe, and particularly about Galls and Oak-apples, I found among no less then 24. several kinds of excress of the Oak, which I doubt not, but upon examination, will be all found to be the matrixes of so many several kinds of Infects; I having observ'd many of them my felf to be so, among 24. several kinds, I fay, I found one described and Figur'd directly like that which I had by me, the scheme is there to be seen, the defoription, because but short, I have here adjoin'd Theatri Botanici trib. 16. Chap. 2. There groweth at the roots of old Oaks in the Spring-time, and femetimes also in the very heat of Summer, a peculiar kind of Musshrom or Excress call'd Uva Quercina, swelling out of the Earth, many growing one close unto another, of the fashion of a Grape, and therefore took the name, the Oak-Grape, and is of a Purplish colour on the outside, and

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and white within like Milk, and in the end of Summer becometh hard and woody. Whether this be the very fame kind, I cannot affirm, but both the Picture and Defcription come very neer to that I have, but that he feems not to take notice of the hollownefs or Worm, for which 'tis most observable. And therefore 'tis very likely, if men did but take notice, they might find very many differing Species of thefe Nuts, Ovaries, or Matrixes, and all of them to have much the fame defignation and office. And I have very lately found feveral kinds of Excrefcencies on Trees and Shrubs, which having endured the Winter, upon opening them, I found most of them to contain little Worms, but dead, those things that contain'd them being wither'd and dry.

Observ. XLIV. Of the tufted or Brush-born'd Gnat.

His little creature was one of those multitudes that fill our English air all the time that warm weather lafts, and is exactly of the fhape of that I observ'd to be generated and hatch'd out of those little Infects that wriggle up and down in Rain-water. But, though many were of this form, yet I observed others to be of quite other kinds; nor were all of this or the other kind generated out of Water Infects; for whereas I observ'd that those that proceeded from those Infects were at their full growth, I have also found multitudes of the same shape, but much smaller and tenderer feeming to be very young ones, creep up and down upon the leaves of Trees, and flying up and down in fmall clufters, in places very remote from water; and this Spring, I observ'd one day, when the Wind was very calm, and the afternoon very fair, and pretty warm, though it had for a long time been very cold weather, and the wind continued still in the East, several small swarms of them playing to and fro in little clouds in the Sun, each of which were not a tenth part of the bignefs of one of these I here have delineated; though very much of the same shape, which makes me ghess, that each of these swarms might be the of-fpring of one onely Gnat, which had been hoorded up in fome fafe repolitory all this Winter by fome provident Parent, and were now, by the warmth of the Spring-air, hatch'd into little Flies. And indeed, fo various, and feemingly irregular are the generations or productions of Infects, that he that shall carefully and diligently observe the feveral methods of Nature therein, will have infinitely caufe further to admire the wildom and providence of the Creator; for not onely the fame kind of creature may be produc'd from several kinds of ways, but the very fame creature may produce feveral kinds: For, as divers Watches may be made out of feveral materials, which may yet have all the fame appearance, and move after the fame manner, that is, fhew the hour equally true, the one as the other, and out of the fame kind of matter, like Watches, may be wrought differing ways; and, as one and the fame Watch may, D d

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MICROGRAPHIA.

may, by being diverfly agitated, or mov'd, by this or that agent, or after this or that manner, produce a quite contrary effect : So may it be with these most curious Engines of Inlect's bodies; the All-wise God of Nature, may have so ordered and disposed the little *Automatons*, that when nourished, acted, or enlivened by this cause, they produce one kind of effect, or animate shape, when by another they act quite another way, and another Animal is produc'd. So may he so order several materials, as to make them, by several kinds of methods, produce several materials.

But to come to the Description of this Insect, as it appears through a Microscope, of which a representation is made in the 28. Scheme. Its head A, is exceeding fmall, in proportion to its body, confifting of two clufters of pearl'd eyes B B, on each fide of its head, whole pearls or eye-balls are curioufly rang'd like those of other Flies; between these, in the forehead of it, there are plac'd upon two fmall black balls, CC, two long jointed horns, tapering towards the top, much refembling the long horns of Lobsters, each of whose stems or quills, DD, were brilled or brushed with multitudes of small stiff hairs, isluing out every way from the several joints, like the strings or sproutings of the herb Horfe-tail, which is oft oblerv'd to grow among Corn, and for the whole fhape, it does very much refemble those brushy Vegetables; befides these, there are two other jointed and brifled horns, or feelers, E E, in the forepart of the head, and a proboscis, F, underneath, which in some Gnats are very long, streight hollow pipes, by which these creatures are able to drill and penetrate the fkin, and thence, through those pipes suck so much bloud as to stuff their bellies fo full till they be ready to burft.

This small head, with its appurtenances, is fastned on by a short neck, G, to the middle of the thorax, which is large, and feems cafed with a ftrong black shel, HIK, out of the under part of which, issue fix long and slender legs, LLLLLL, fhap'd just like the legs of Flies, but spun or drawn out longer and flenderer, which could not be express'd in the Figure, because of their great length; and from the upper part, two oblong, but flender transparent wings, MM, shaped fomewhat like those of a Fly, underneath each of which, as I have obferv'd also in divers forts of Flies, and other kinds of Gnats, was placed a fmall body, N, much refembling a drop of some transparent glutinous substance, hardned or cool'd, as it was almost ready to fall, for it has a round knob at the end, which by degrees grows flenderer into a small stem, and neer the infertion under the wing, this ftem again grows bigger ; these little Pendulums, as I may fo call them, the litle creature vibrates to and fro very quick when it moves its wings, and I have fometimes observ'd it to move them also, whil'ft the wing lay still, but always their motion feem'd to further the motion of the wing ready to follow; of what use they are, as to the moving of the wing, or otherwife, I have not now time to examine. Its belly was large, as it is ufually in all Infects, and extended into nine lengths or partitions, each of which was cover'd with round armed rings or shells; fix of which, OPQRST were transparent, and divers kinds of Peristaltick motions might be very eafily perceiv'd, whil'st the Animal was Was aliv the hear ver'd wi altogeth with the feem to l thole wh

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Was alive, but effectially a fmall cleer white part V, feemed to beat like the heart of a larger Animal. The laft three divisios, W X Y, were cover'd with black and opacous shells. To conclude, take this creature altogether, and for beauty and curious contrivances, it may be compared with the largest Animal upon the Earth. Nor doth the Alwise Creator feem to have shewn less care and providence in the fabrick of it, then in those which feem most confiderable.

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Observ. XLV. Of the great Belly'd Gnat or female Gnat.

The fecond Gnat, delineated in the twenty ninth Scheme, is of a very differing fhape from the former; but yet of this fort alfo, I found feveral of the Gnats, that were generated out of the Water Infect: the wings of this, were much larger then those of the other, and the belly much bigger, fhorter and of an other fhape; and, from feveral particulars, I gheft it to be the Female Gnat, and the former to be the Male.

The *thor ax* of this, was much like that of the other, having a very ftrong and ridged back-piece, which went alfo on either fide of its leggs; about the wings there were feveral joynted pieces of Armor, which feem'd curioufly and conveniently contriv'd, for the promoting and ftrengthning the motion of the wings: its head was much differing from the other, being much bigger and neater fhap'd, and the horns that grew out between his eyes on two little balls, were of a very differing fhape from the tufts of the other Gnat, thefe having but a few knots or joynts, and each of thofe but a few, and thofe fhort and ftrong, britles. The formoft horns or feelers, were like thofe of the former Gnat.

One of these Gnats I have suffer'd to pierce the skin of my hand, with its proboscis, and thence to draw out as much blood as to fill its belly as full as it could hold, making it appear very red and transparent; and this without any further pain, then whil st it was sinking in its proboscis, as it is also in the stinging of Fleas: a good argument, that these creatures do not wound the skin, and suck the blood out of enmity and revenge, but for meer necessity, and to satisfy their hunger. By what means this creature is able to suck, we shall shew in another place.

Observ. XLVI. Of the white featherwing'd Moth or Tinea Argentea.

T His white long wing'd Moth, which is delineated in the 30. Schemes afforded a lovely object both to the naked Eye, and through a Microscope: to the Eye it appear'd a small Milk white Fly with four white D d 2 Wings

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Wings, the two formoft fomewhat longer then the two hindermoft, and the two fhorter about half an Inch long, each of which four Wings feem'd to confift of two fmall long Feathers, very curioufly tufted, or haired on each fide, with purely white, and exceedingly fine and fmall Haires, proportion'd to the ftalks or ftems, out of which they grew, much like the tufts of a long wing-feather of fome Bird, and their ftalks or ftems were, like those, bended backwards and downwards, as may be plainly feen by the draughts of them in the Figure.

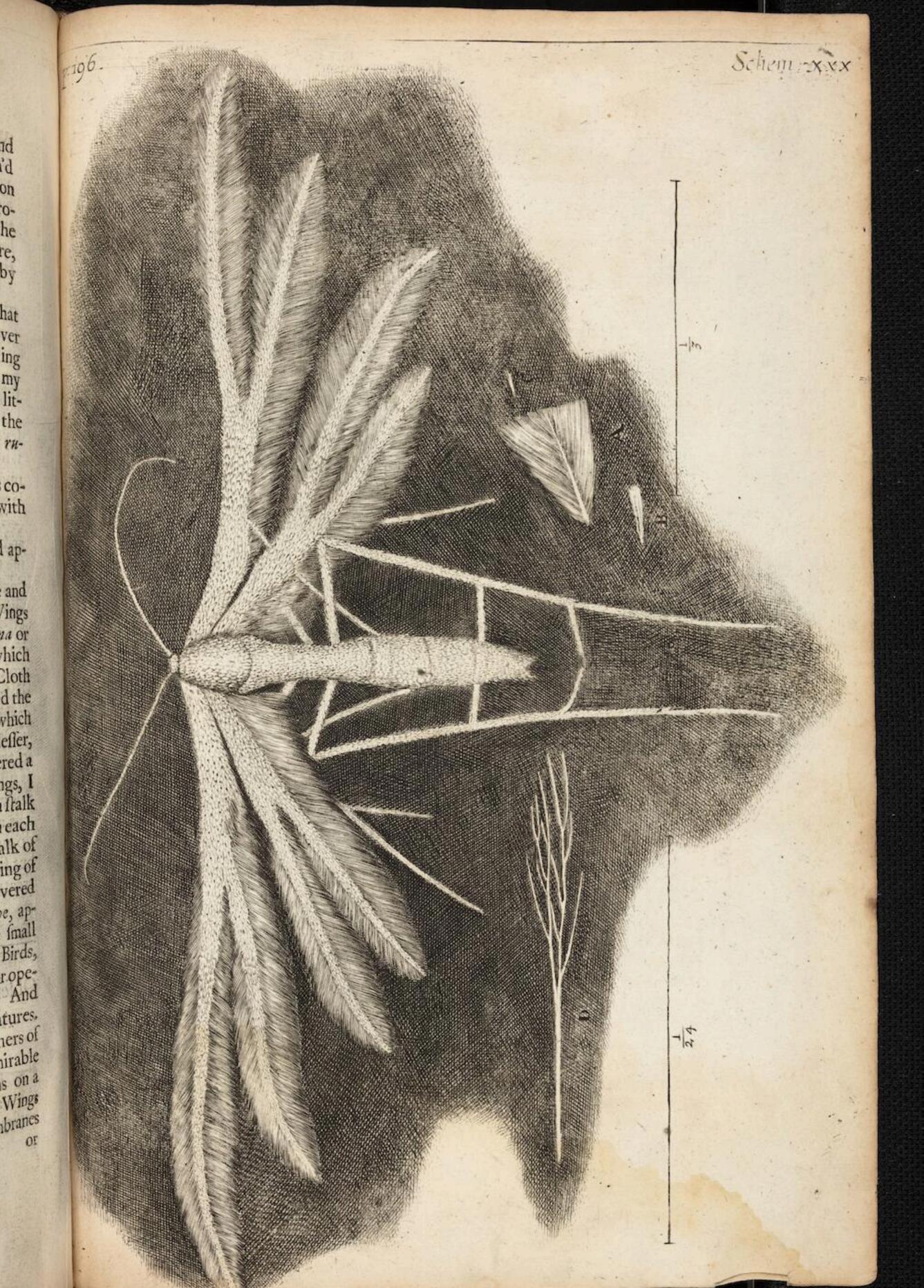
Obferving one of these in my *Microscope*, I found, in the first place, that all the Body, Legs, Horns and the Stalks of the Wings, were covered over with various kinds of curious white Feathers, which did, with handling or touching, easily rubb off and fly about, in so much that looking on my Fingers, with which I had handled this Moth, and perceiving on them little white specks, I found by my *Microscope*, that they were several of the small Feathers of this little creature, that stuck up and down in the *rugosities* of my Skin.

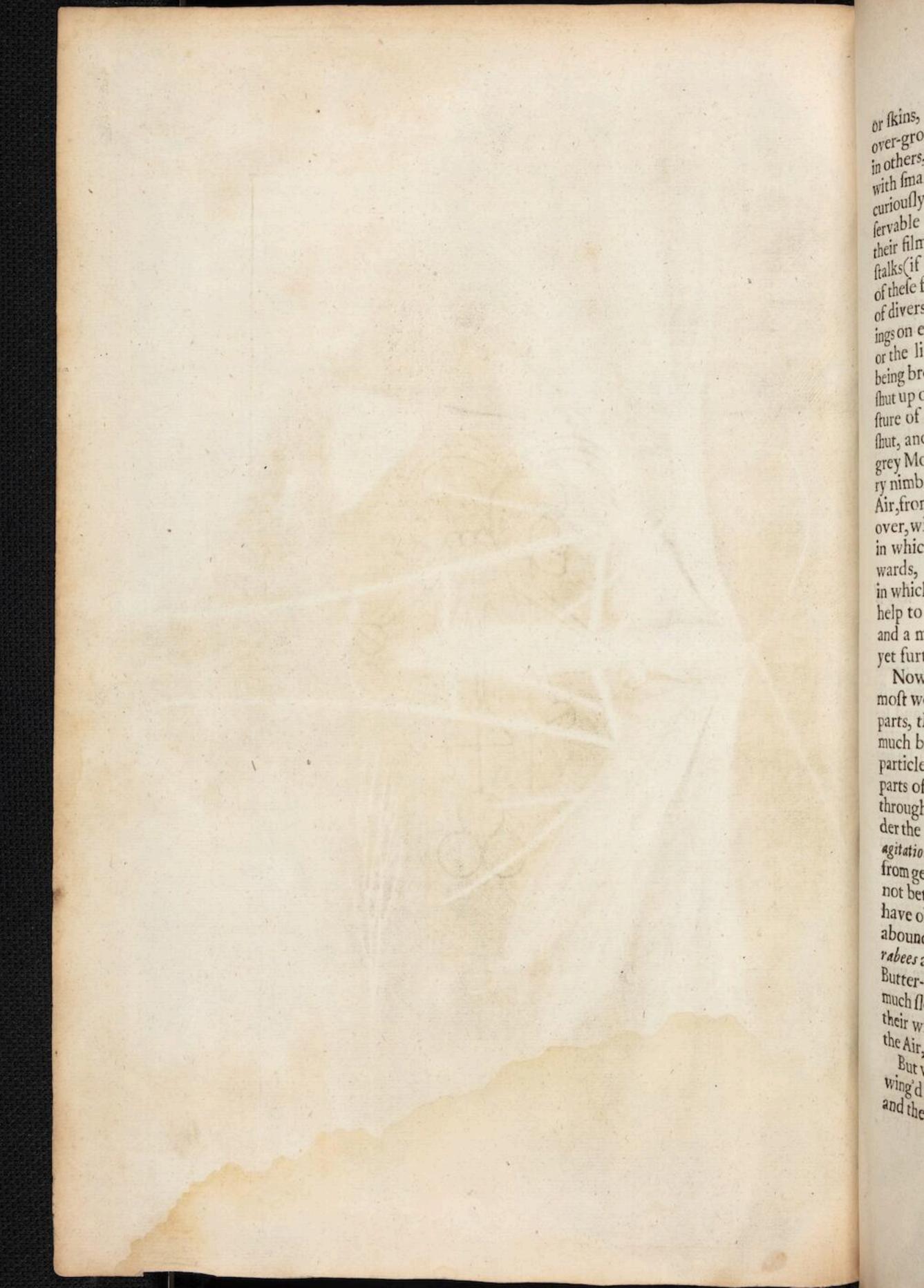
Next, I found that underneath these Feathers, the pretty Infect was covered all over with a crufted Shell, like other of those Animals, but with one much thinner and tenderer.

Thirdly, I found, as in Birds also is notable, it had differing and appropriate kinds of Feathers, that covered feveral parts of its body.

Fourthly, furveying the parts of its body, with a more accurate and better Magnifying Microscope, I found that the tufts or haires of its Wings were nothing else but a congeries, or thick set cluster of small vimina or twiggs, refembling a fmall twigg of Birch, ftript or whitned, with which Brushes are usually made, to beat out or brush off the dust from Cloth and Hangings. Every one of the twiggs or branches that composed the Brush of the Feathers, appeared in this bigger Magnifying Glass (of which E F which reprefents $\frac{1}{24}$ part of an Inch, is the scale, as G is of the lefter, which is only 1) like the figure D. The Feathers also that covered a part of his Body, and were interfperfed among the brush of his Wings, I found, in the bigger Magnifying Glafs, of the fhape A, confifting of a stalk or frem in the middle, and a feeming tuftedness or brushy part on each fide. The Feathers that cover'd most part of his Body and the stalk of his wings, were, in the fame Microscope, much of the figure B, appearing of the shape of a small Feather, and seemed tufted : those which covered the Horns and fmall parts of the Leggs, through the fame Microfcope, appear'd of the shape C. Whether the tufts of any or all of these small Feathers, confifted of fuch component particles as the Feathers of Birds, I much doubt, becaufe I find that Nature does not alwaies keep, or operate after the fame method, in fmaller and bigger creatures. And of this, we have particular Inftances in the Wings of feveral creatures. For whereas, in Birds of all kinds, it composes each of the Feathers of which its Wing confifts, of fuch an exceeding curious and most admirable and stupendious texture, as I else where shew, in the Observations on a Feather; we find it to alter its method quite, in the fabrick of the Wings of these minute creatures, composing some of thin extended membranes

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or skins, such as the Wings of Dragon-flys; in others, those skins are all over-grown, or pretty thick beftuck, with fhort brifles, as in Flefh-flies ; in others, those filmes are covered, both on the upper and under fide, with fmall Feathers, plac'd almost like the tyles on a House, and are curioufly rang'd and adorn'd with most lively colours, as is obfervable in Butter-flies, and feveral kinds of Moths; In others, inftead of their films, Nature has provided nothing, but a matter of half a fcore ftalks(if I well remember the number; for I have not lately met with any of these flys, and did not, when I first observ'd them, take sufficient notice of divers particulars) and each of these stalks, with a few single branchings on each fide, refembling much the branched back-bone of a Herring or the like Fish, or a thin hair'd Peacocks feather, the top or the eye being broken off. With a few of these on either fide(which it was able to fhut up or expand at pleasure, much like a Fann, or rather like the pofture of the feathers in a wing, which ly all one under another, when fhut, and by the fide of each other, when expanded) this pretty little grey Moth (for fuch was the creature I observ'd, thus wing'd) could very nimbly, and as it feem'd very eafily move its corpufcle, through the Air, from place to place. Other Infects have their wings cas'd, or cover'd over, with certain hollow fhells, fhap'd almost like those hollow Trayes, in which Butchers carry meat, whofe hollow fides being turn'd downwards, do not only fecure their folded wings from injury of the earth, in which most of those creatures reside, but whilst they fly, ferves as a help to fustain and bear them up. And these are observable in scarabees and a multitude of other terrestrial crustaceous Infects ; in which we may yet further observe a particular providence of Nature.

Now in all these kinds of wings, we observe this particular, as a thing most worthy remark; that where ever a wing confists of discontinued parts, the Pores or interstitia between those parts are very feldom, either much bigger, or much smaller, then these which we here find between the particles of these brushes, so that it should seem to intimate, that the parts of the Air are fuch, that they will not eafily or readily, if at all, pass through these Pores, so that they seem to be strainers fine enough to hinder the particles of the Air (whether hinder'd by their bulk, or by their agitation, circulation, rotation or undulation, I shall not here determine) from getting through them, and, by that means, ferve the Animal as well, if not better, then if they were little films. I fay, if not better, becaufe I have observ'd that all those creatures, that have film'd wings, move them aboundantly quicker and more strongly, such as all kind of Flies and Scarabees and Batts, then fuch as have their wings covered with feathers, as Butter-flies and Birds, or twiggs, as Moths, which have each of them a much flower motion of their wings; That little ruggedness perhaps of their wings helping them fomewhat, by taking better hold of the parts of the Air, or not fuffering them fo eafily to pass by, any other way then one. But what ever be the reason of it, 'tis most evident, that the smooth wing'd Infects have the ftrongeft Muscles or movent parts of their wings, and the other much weaker; and this very Infect, we are now deferibing,

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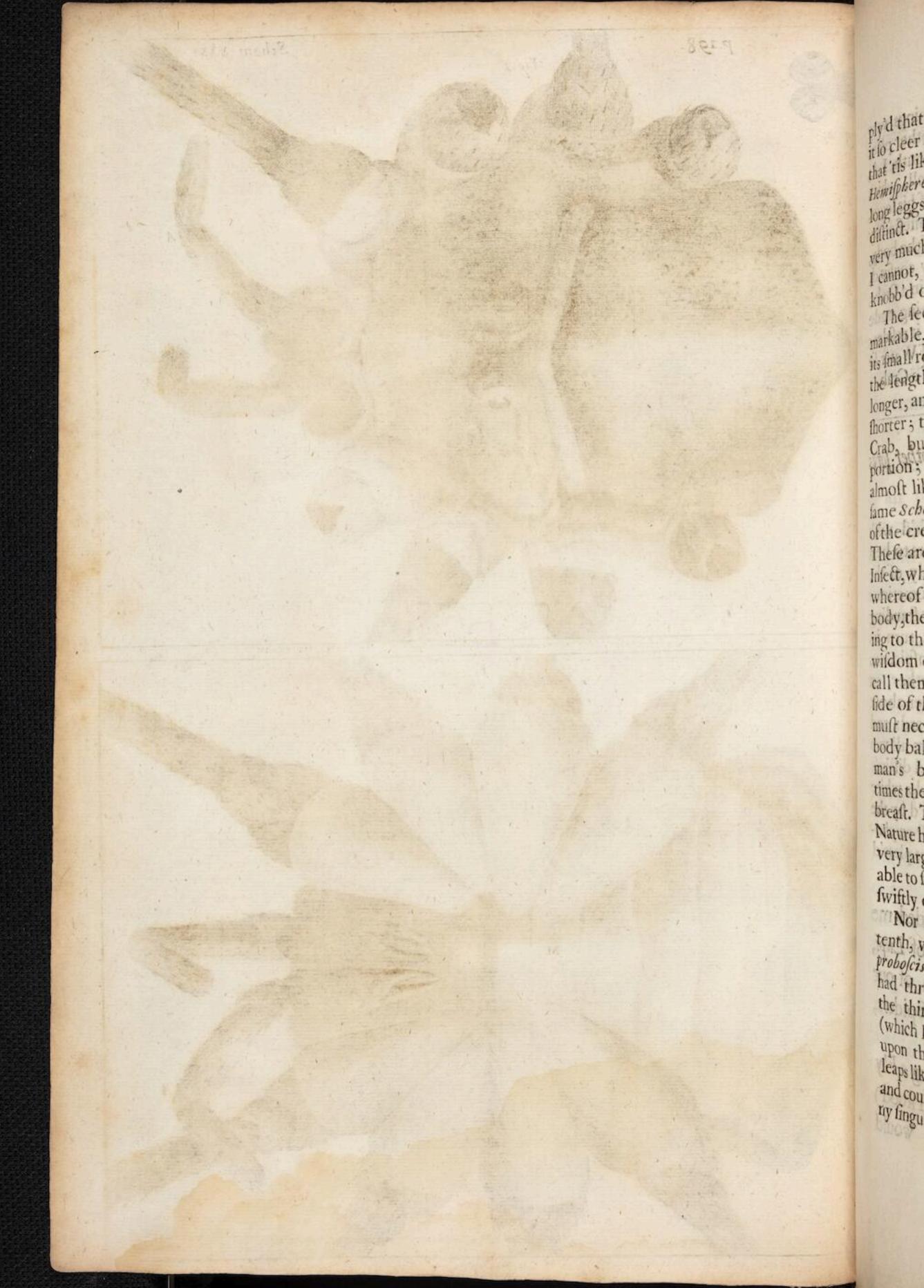
had a very fmall *thorax* or middle part of his body, if compar'd to the length and number of his wings; which therefore, as he mov'd them very flowly fo muft he move them very weakly. And this laft propriety do we find fomewhat obferv'd alfo in bigger kind of Flying creatures, Birds; fo that we fee that the Wifdom and Providence of the All-wife Creator, is not lefs fhewn in thefe fmall defpicable creatures, Flies and Moths, which we have branded with a name of ignominy, calling them Vermine, then in those greater and more remakable animate bodies, Birds.

I cannot here ftand to add any thing about the nature of flying, though, perhaps, on another occafion, I may fay fomething on that fubject, it being fuch as may deferve a much more accurate examination and fcrutiny then it has hitherto met with; For to me there feems nothing wanting to make a man able to fly, but what may be eafily enough fupply'd from the Mechanicks hitherto known, fave onely the want of ftrength, which the Mufcles of a man feem utterly uncapable of, by reafon of their fmalnefs and texture, but how even ftrength alfo may be mechanically made, an artificial Mufcle fo contriv'd, that thereby a man fhall be able to exert what ftrength he pleafes, and to regulate it alfo to his own mind, I may elfewhere endeavour to manifeft.

Observ. XLVII. Of the Shepherd Spider, or long legg'd Spider.

THe Carter, Shepherd Spider, or long-legg'd Spider, has, for two particularities, very few fimilar creatures that I have met with; the first, which is discoverable onely by the Microscope, and is in the first and second Figures of the 31. scheme, plainly describ'd, is the curious contrivance of his eyes, of which (differing from moft other Spiders) he has onely two, and those plac'd upon the top of a small pillar or hillock, rising out of the middle of the top of its back, or rather the crown of its head, for they were fix'd on the very top of this pillar (which is about the heighth of one of the transverse Diameters of the eye, and look'd on in another posture, appear'd much of the shape, BCD) The two eyes, BB, were placedback to back, with the transparent parts, or the pupils, looking towards either fide, but fomewhat more forward then backwards. C was the column or neck on which they ftood, and D the crown of the head out of which that neck fprung. These eyes, to appearance, seem'd to be of the very same structure with that of larger binocular creatures, feeming to have a very fmooth and very protuberant Cornea, and in the midst of it to have a very black pupil, incompassed about with a kind of grey Iris, as appears by the Figure; whether it were able to move these eyes to and fro, I have not observ'd, but 'tis not very likely he should, the pillar or neck C, seeming to be cover'd and stiffen'd with a crusty shell; but Nature, in probability, has supply'd





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ply'd that defect, by making the *Cornea* fo very protuberant, and fetting it fo cleer above the fhadowing or obftructing of its profpect by the body, that 'tis likely each eye may perceive, though not fee diftinctly; almost a *Hemisphere*, whence having fo fmall and round a body plac'd upon fuch long leggs, it is quickly able fo to wind, and turn it, as to fee any thing diftinct. This creature, as do all other Spiders I have yet examin'd, does very much differ from most other Infects in the Figure of its eyes; for I cannot, with my best *Microscope*, difcover its eyes to be any ways knobb'd or pearl'd like those of other Infects.

The fecond Peculiarity which is obvious to the eye, is also very remarkable, and that is the prodigious length of its leggs, in proportion to its fmall round body, each legg of this I drew, being above fixteen times the length of its whole body, and there are fome which have them yet longer, and others that feem of the fame kind, that have them a great deal fhorter; the eight leggs are each of them jointed, just like those of a Crab, but every of the parts are fpun our prodigiously longer in proportion; each of these leggs are terminated in a small case or shell, shap'd almost like that of a Musle-shell, as is evident in the third Figure of the fame scheme (that reprefents the appearance of the under part or belly of the creature) by the fhape of the protuberant conical body, IIII, O.c. These are as 'twere plac'd or fasten'd on to the protuberant body of the Infect, which is to be supposed very high at M, making a kind of blunt cone whereof M is to be suppos'd the Apex, about which greater cone of the body, the smaller cones of the leggs are plac'd, each of them almost reaching to the top in fo admirable a manner, as does not a little manifeft the wildom of Nature in the contrivance; for thele long Leavers (as I may fo call them) of the legs, having not the advantage of a long end on the other fide of the hypomochlion or centers on which the parts of the leggs move, must necessarily require a vast strength to move them, and keep the body ballanc'd and fuspended, in fo much, that if we should suppose a man's body fufpended by fuch a contrivance, an hundred and fifty times the strength of a man would not keep the body from falling on the breaft. To fupply therefore each of these leggs with its proper strength, Nature has allow'd to each a large Cheft or Cell, in which is included a very large and ftrong Muscle, and thereby this little Animal is not onely able to fuspend its body upon lefs then these eight, but to move it very fwiftly over the tops of grafs and leaves. Nor are these eight leggs to prodigiously long, but the ninth, and tenth, which are the two claws, K K, are as fhort, and ferve in freed of a probofcis, for those feem'd very little longer then his mouth; each of them had three parts, but very fhort, the joints K K, which reprefented the third, being longer then both the other. This creature, feems (which I have feveral times with pleafure observ'd) to throw its body upon the prey, infreed of its hands, not unlike a hunting Spider, which leaps like a Cat at a Moufe. The whole Fabrick was a very pretty one, and could I have diffected it, I doubt not but I thould have found as many fingularities within it as without, perhaps, for the most part, not unlike the

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the parts of a Crab, which this little creature does in many things, very much refemble; the curiofity of whofe contrivance, I have in another place examin'd. I omit the defcription of the horns, A A, of the mouth, L L, which feem'd like that of a Crab; the fpecklednefs of his fhell, which proceeded from a kind of feathers or hairs, and the hairinefs of his leggs, his large *thorax* and little belly, and the like, they being manifefted by the Figure; and fhall onely take notice that the three parts of the body, namely, the head, breaft, and belly, are in this creature ftrangely confus d, fo that 'tis difficult to determine which is which, as they are alfo in a Crab; and indeed, this feems to be nothing elfe, but an Air-crab, being made more light and nimble, proportionable to the *medium* wherin it refides; and as Air feems to have but one thoufandth part of the body of Water, fo does this Spider feem not to be a thoufandth part of the bulk of a Crab.

Observ. XLVIII. Of the hunting Spider, and several other forts of Spiders.

T'He hunting Spider is a small grey Spider, prettily bespeck'd with black spots all over its body, which the Microscope discovers to be a kind of feathers like those on Butterflies wings, or the body of the white Moth I lately defcrib'd. Its gate is very nimble by fits, fometimes running, and fometimes leaping, like a Grafhopper almost, then standing still, and setting it felf on its hinder leggs, it will very nimbly turn its body, and look round it felf every way: It has fix very confpicuous eyes, two looking directly forwards, plac'd just before; two other, on either fide of those, looking forward and fide-ways; and two other about the middle of the top of its back or head, which look backwards and fide-wards; these feem'd to be the biggest. The surface of them all was very black, spharical, purely polish'd, reflecting a very cleer and distinct Image of all the ambient objects, fuch as a window, a man's hand, a white Paper, or the like. Some other properties of this Spider, observ'd by the most accomplish'd Mr. Evelyn, in his travels in Italy, are most emphatically fet forth in the Hiftory hereunto annexed, which he was pleas'd upon my defire to fend me in writing.

would n being ar its aim ; oppofite taking b the Fly's tent leap Thadow unless th the fame if the fa whether at all t the cap behind nimbly which n to appe into the riv'd w (fwift a where 1 carried their yo disciplin ones di the field haply n long ha templati amaz'd ning ar ders in

Of all the forts of Infects, there is none has afforded me more divertifements then the Venatores, which are a fort of Lupi, that have their Denns in the rugged walls, and crevices of our houfes; a fmall brown and delicately fpotted kind of Spiders, whofe hinder leggs are longer then the reft. Such I did frequently obferve at Rome, which efpying a Fly at three or four yards diftance, upon the Balcony (where I ftood) would

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would not make directly to her, but craul under the Rail, till being arr iv'd to the Antipodes, it would fteal up, feldom miffing, its aim; but if it chanced to want any thing of being perfectly opposite, would at first peep, immediatly flide down again, till taking better notice, it would come the next time exactly upon the Fly's back : But, if this hapn'd not to be within a competent leap, then would this Infect move fo foftly, as the very fhadow of the Gnomon feem'd not to be more imperceptible, unless the Fly mov'd; and then would the Spider move also in the fame proportion, keeping that just time with her motion, as if the fame Soul had animated both those little bodies; and whether it were forwards, backwards, or to either fide, without at all turning her body, like a well mannag'd Horfe : But, if the capricious Fly took wing, and pitch'd upon another place behind our Huntrefs, then would the Spider whirle its body fo nimbly about, as nothing could be imagin'd more fwift; by which means, the always kept the head towards her prey, though to appearance, as immovable, as if it had been a Nail driven into the Wood, till by that indifcernable progress (being arriv'd within the sphere of her reach) she made a fatal leap (fwift as Lightning) upon the Fly, catching him in the pole, where she never quitted hold till her belly was full, and then carried the remainder home. I have beheld them inftructing their young ones, how to hunt, which they would fometimes discipline for not well observing; but, when any of the old ones did (as sometimes) miss a leap, they would run out of the field, and hide them in their crannies, as afham'd, and haply not be feen abroad for four or five hours after; for fo long have I watched the nature of this strange Infect, the contemplation of whole fo wonderfull fagacity and address has amaz'd me; nor do I find in any chafe whatfoever, more cunning and Stratagem observ'd : I have found some of these Spiders in my Garden, when the weather (towards the Spring) Ee 15

is very hot, but they are nothing fo eager of hunting as they being are in Italy, being are in Ital up, feld up, feld up,

There are multitudes of other forts of Spiders, whole eyes, and molt other parts and properties, are fo exceedingly different both from those I have defcrib'd, and from one another, that it would be almost endles, at least too long for my prefent Eslay, to describe them, as some with fix eyes, plac'd in quite another order ; others with eight eyes; others with fewer, and fome with more. They all feem to be creatures of prey, and to feed on other small Infects, but their ways of catching them feem very differing : the Shepherd Spider by running on his prey ; the Hunting Spider by leaping on it, other forts weave Nets, or Cobwebs, whereby they enfnare them, Nature having both fitted them with materials and tools, and taught them how to work and weave their Nets, and to lie perdue, and to watch diligently to run on any Fly, as foon as ever entangled.

Their thread or web feems to be fpun out of fome vifcous kind of excrement, lying in their belly, which, though foft when drawn out, is, prefently by reafon of its fmalnefs, hardned and dried by the ambient Air. Examining feveral of which with my Microscope, I found them to appear much like white Horf-hair, or fome fuch transparent horny substance, and to be of very differing magnitudes; fome appearing as bigg as a Pigg's brille, others equal to a Horfs-hair; other no bigger then a man's hair; others yet smaller and finer. I observed further, that the radiating chords of the web were much bigger, and fmoother then those that were woven round, which feem'd fmaller, and all over knotted or pearl'd, with small transparent Globules, not unlike small Crystal Beads or feed Pearls, thin strung on a Clew of Silk; which, whether they were fo fpun by the Spider, or by the adventitious moisture of a fogg (which I have observ'd to cover all these filaments with such Crystalline Beads) I will not now dispute.

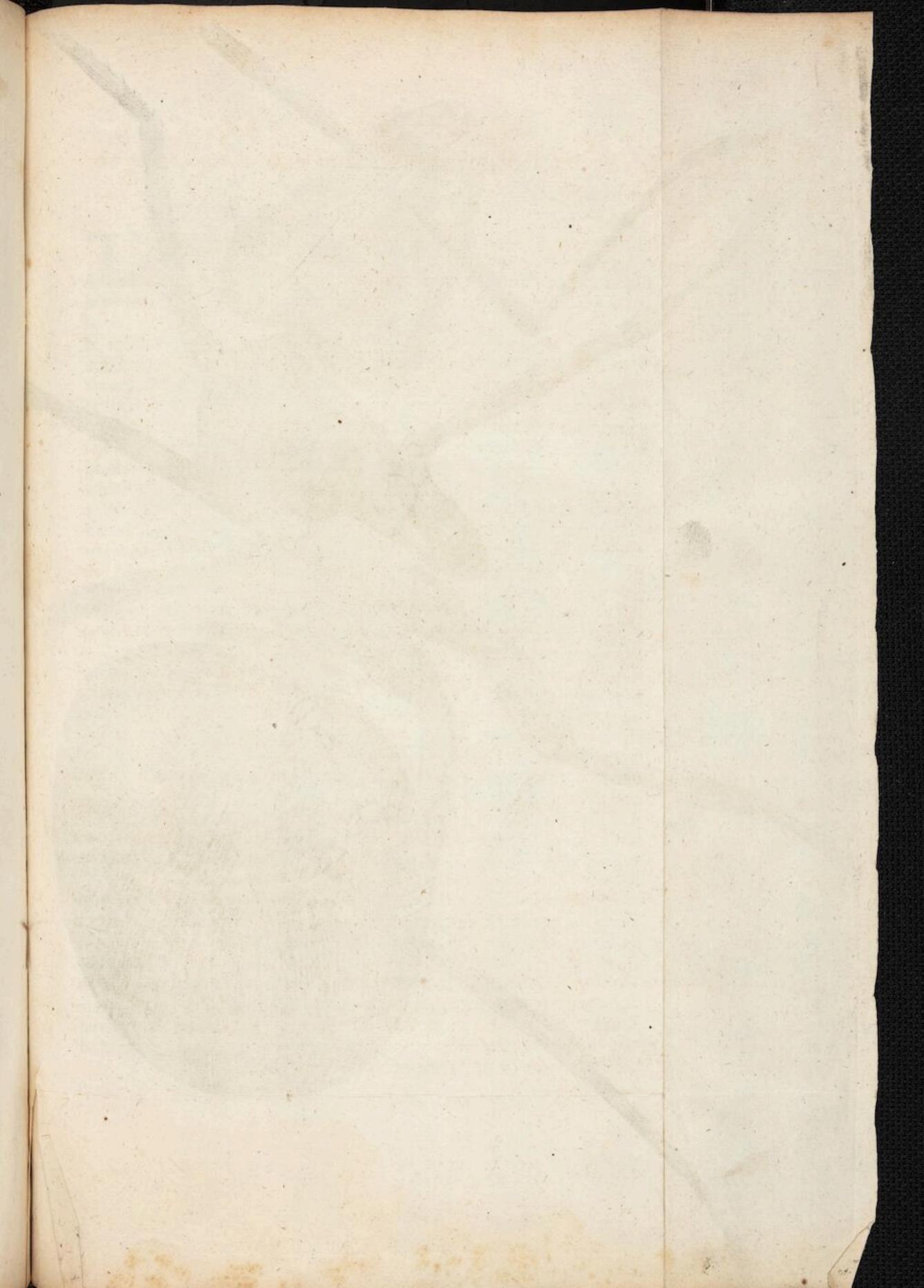
These threads were some of them so small, that I could very plainly, with the Microscope, discover the same confecutions of colours as in a Prisme, and they seem'd to proceed from the same cause with those colours which I have already defcrib'd in thin plated bodies.

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Much refembling a Cobweb, or a confus'd lock of these Cylinders, is a certain white substance which, after a fogg, may be observed to fly up and down the Air; catching feveral of thefe, and examining them with my Microscope, I found them to be much of the fame form, looking most like to a flake of Worsted prepar'd to be spun, though by what means they fhould be generated, or produc'd, is not eafily imagined : they were of the fame weight, or very little heavier then the Air ; and 'tis not unlikely, but that those great white clouds, that appear all the Summer time, may be of the fame fubstance.

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ders in my Garden. When the weather (towards the ppring Obferv.





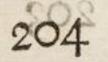
Observ. XLIX. Of an Ant or Pifmire. His was a creature, more troublesom to be drawn, then any of the

reft, for I could not, for a good while, think of a way to make it fuffer its body to ly quiet in a natural posture; but whil'st it was alive, if its feet were fetter d in Wax or Glew, it would fo twift and wind its body, that I could not any wayes get a good view of it; and if I killed it, its body was so little, that I did often spoile the shape of it, before I could throughly view it: for this is the nature of these minute Bodies, that as foon, almost, as ever their life is destroy'd, their parts immediately shrivel, and lose their beauty; and so is it also with small Plants, as I inftanced before, in the description of Moss. And thence also is the reafon of the variations in the beards of wild Oats, and in those of Muskgrafs feed, that their bodies, being exceeding fmall, those fmall variations which are made in the furfaces of all bodies, almost upon every change of Air, especially if the body be porous, do here become fensible, where the whole body is fo fmall, that it is almost nothing but furface; for as in vegetable fubstances, I fee no great reason to think, that the moisture of the Aire(that, fticking to a wreath'd beard, does make it untwift) should evaporate, or exhale away, any faster then the moisture of other bodies, but rather that the avolation from, or access of moifture to, the furfaces of bodies being much the same, those bodies become most sensible of it, which have the least proportion of body to their surface. So is it also with Animal fubftances; the dead body of an Ant, or fuch little creature, does almost instantly shrivel and dry, and your object shall be quite another thing, before you can half delineate it, which proceeds not from the extraordinary exhalation, but from the small proportion of body and juices, to the usual drying of bodies in the Air, especially if warm. For which inconvenience, where I could not otherwife remove it, I thought of this expedient.

I took the creature, I had defign'd to delineate, and put it into a drop

of very well rectified fpirit of Wine, this I found would prefently difpatch, as it were, the Animal, and being taken out of it, and lay'd on a paper, the fpirit of Wine would immediately fly away, and leave the Animal dry, in its natural pofture, or at leaft, in a conftitution, that it might eafily with a pin be plac'd, in what pofture you defired to draw it, and the limbs would fo remain, without either moving, or fhriveling. And thus I dealt with this Ant, which I have here delineated, which was one of many, of a very large kind, that inhabited under the Roots of a Tree, from whence they would fally out in great parties, and make most grievous havock of the Flowers and Fruits, in the ambient Garden, and return back again very expertly, by the fame wayes and paths they went.

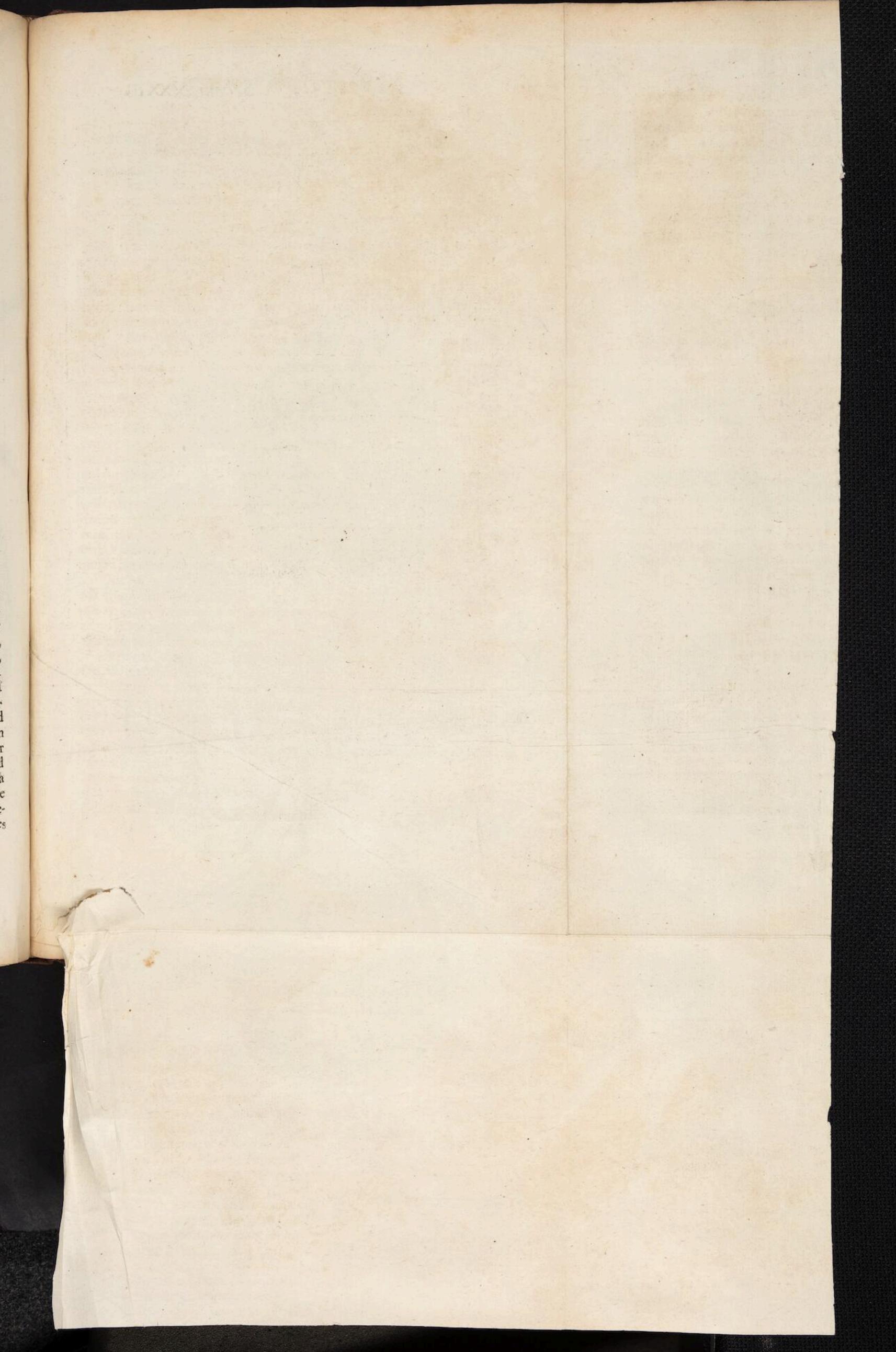
It was more then half the bignels of an Earwig, of a dark brown, or reddifh colour, with long legs, on the hinder of which it would stand E e 2 up,

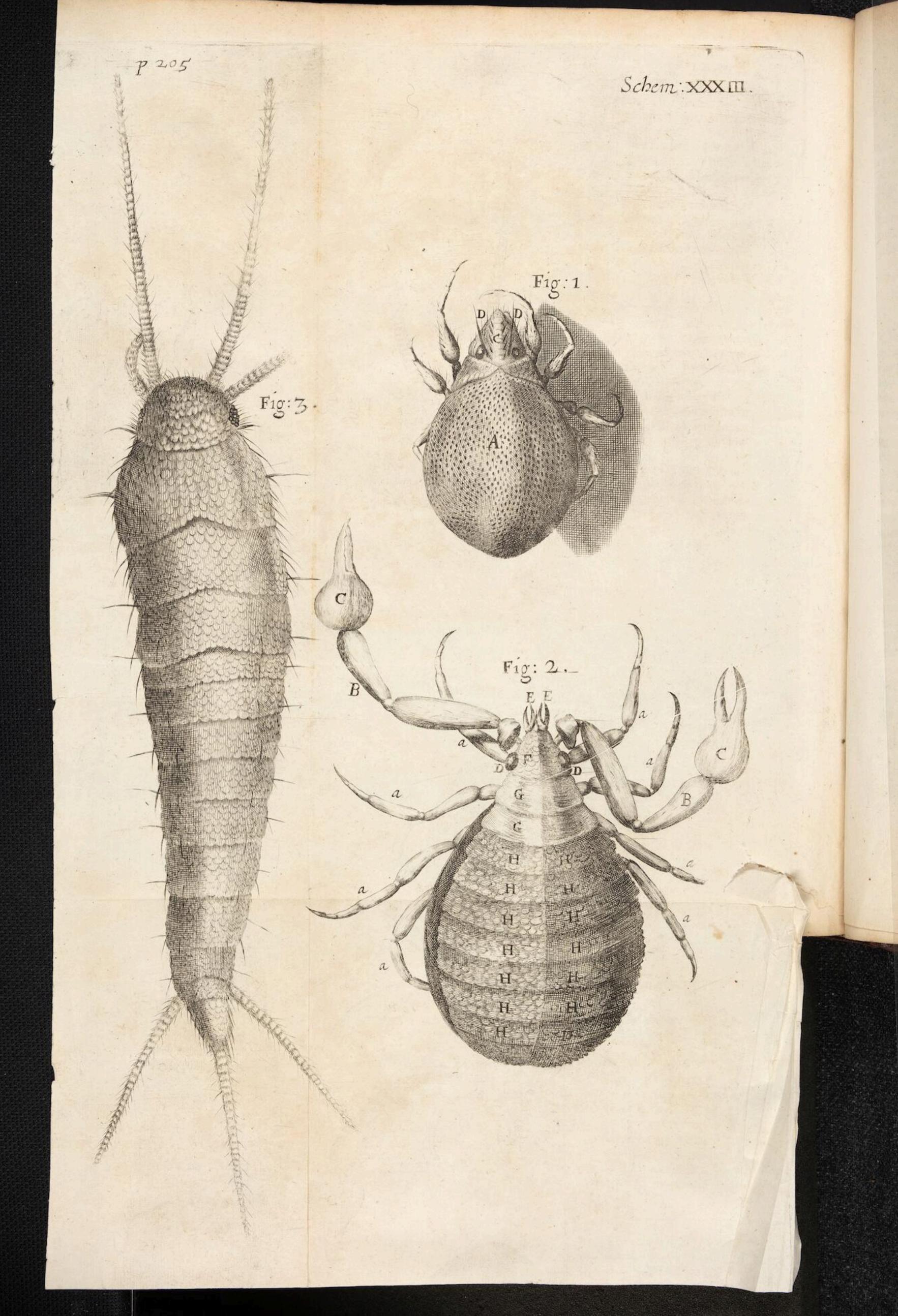


up, and raife its head as high as it could above the ground, that it might ftare the further about it, just after the fame manner as I have alfo obferv'd a hunting Spider to do: and putting my finger towards them, they have at first all run towards it, till almost at it; and then they would ftand round about it, at a certain distance, and fmell, as it were, and confider whether they should any of them venture any further, till one more bold then the reft venturing to climb it, all the reft, if I would have fuffered them, would have immediately followed : many fuch other feemingly rational actions I have observed in this little Vermine with much pleafure, which would be too long to be here related; those that defire more of them may fatisfie their curiofity in *Ligons* History of the *Barbadoes*.

Having infnar'd feveral of these into a small Box, I made choice of the talleft grown among them, and separating it from the reft, I gave it a Gill of Brandy, or Spirit of Wine, which after a while e'en knock'd him down dead drunk, fo that he became movelefs, though at first putting in he struggled for a pretty while very much, till at last, certain bubbles isluing out of its mouth, it cealed to move; this (becaufe I had before found them quickly to recover again, if they were taken out prefently) I suffered to lye above an hour in the Spirit; and after I had taken it out, and put its body and legs into a natural posture, remained moveless about an hour; but then, upon a sudden, as if it had been awaken out of a drunken fleep, it fuddenly reviv'd and ran away; being caught, and ferv'd as before, he for a while continued ftruggling and striving, till at last there issued several bubbles out of its mouth, and then, tanquam animam expirasset, he remained moveless for a good while ; but at length again recovering, it was again redipt, and fuffered to lye fome hours in the Spirit; notwithstanding which, after it had layen dry fome three or four hours, it again recovered life and motion : Which kind of Experiments, if profecuted, which they highly deferve, feem to me of no inconfiderable use towards the invention of the Latent Scheme, (as the Noble Verulam calls it) or the hidden, unknown Texture of Bodies.

Of what Figure this Creature appear'd through the Microscope, the 32. Scheme (though not so carefully graven as it ought) will reprefent to the eye, namely, That it had a large head A A, at the upper end of which were two protuberant eyes, pearl'd like those of a Fly, but smaller BB; out of the Nose, or foremost part, issued two horns CC, of a shape sufficiently differing from those of a blew Fly, though indeed they feem to be both the fame kind of Organ, and to ferve for a kind of fmelling; beyond these were two indented jaws DD, which he open'd fide-wayes, and was able to gape them afunder very wide; and the ends of them being armed with teeth, which meeting went between each other, it was able to grafp and hold a heavy body, three or four times the bulk and weight of its own body: It had only fix legs, shap'd like those of a Fly, which, as I shewed before, is an Argument that it is a winged Infect, and though I could not perceive any fign of them in the middle part of its body (which seem'd to confist of three joints or pieces





ces EF G, out of which fprung two legs, yet tis known that there are of them that have long wings, and fly up and down in the air.

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The third and laft part of its body III was bigger and larger then the other two, unto which it was joyn'd by a very fmall middle, and had a kind of loofe shell, or another distinct part of its body H, which seem'd to be interpos'd, and to keep the *thorax* and belly from touching.

The whole body was cas'd over with a very ftrong armour, and the belly III was covered likewife with multitudes of fmall white fhining brifles; the legs, horns, head, and middle parts of its body were befruck with hairs alfo, but fmaller and darker.

ic being able very calify to tumble a flone or clod four times as big as its

Observ. L. Of the wandring Mite.

IN September and October, 1661. I observed in Oxford several of these little pretty Creatures to wander to and fro, and often to travel over the plains of my Window. And in September and October. 1663. I obferved likewise several of these very same Creatures traversing a window at London, and looking without the window upon the subjacent wall, I found whole flocks of the same kind running to and fro among the small groves and thickets of green moss, and upon the curiously spreading vegetable blew or yellow moss, which is a kind of a Mushrome or Jewscar.

These Creatures to the naked eye seemed to be a kind of black Mite, but much nimbler and stronger then the ordinary Cheese-Mites; but examining them in a *Microscope*, I found them to be a very fine crusted or shell'd Infect, much like that represented in the first Figure of the three and thirtieth *Scheme*, with a protuberant oval shell A, indented or pitted with an abundance of small pits, all covered over with little white briss, whose points all directed backwards.

It had eight legs, each of them provided with a very sharp tallon, or claw at the end, which this little Animal, in its going, faitned into the pores of the body over which it went. Each of these legs were bestuck in every joynt of them with multitudes of small hairs, or (if we refpect the proportion they bore to the bigness of the leg) turnpikes, all pointing towards the claws. The Thorax, or middle parts of the body of this Creature, was exceeding fmall, in respect both of the head and belly, it being nothing but that part which was covered by the two shells BB, though it feem'd to grow thicker underneath: And indeed, if we confider the great variety Nature uses in proportioning the three parts of the body, the Head, Thorax, and Belly) we shall not wonder at the small proportion of this Thorax, nor at the vafter bulk of the belly, for could we exactly anatomife this little Creature, and observe the particular defigns of each part, we should doubtless, as we do in all her more manageable

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nageable and tractable fabricks, find much more reason to admire the excellency of her contrivance and workmanship, then to wonder, it was not made otherwise.

The head of this little Infect was ihap'd fomewhat like a Mite's, that is, it had a long fnout, in the manner of a Hogs, with a knobbed ridge running along the middle of it, which was beftuck on either fide with many fmall brifles, all pointing forward, and two very large pikes or horns, which role from the top of the head, juft over each eye, and pointed forward alfo. It had two pretty large black eyes on either fide of the head E E, from one of which I could fee a very bright reflection of the window, which made me ghefs, that the *Cornea* of it was fmooth, like those of bigger Infects. Its motion was pretty quick and ftrong, it being able very eafily to tumble a ftone or clod four times as big as its whole body.

At the fame time and place, and diverstimes fince, I have obferved with my *Microfcope*, another little Infect, which, though I have not annexed the picture of, may be worth noting, for its exceeding nimblenefs as well as fmalnefs; it was as fmall as a Mite, with a body deep and ridged, almost like a Flea; it had eight blood-red legs, not very long, but flender; and two horns or feelers before. Its motion was fo exceeding quick, that I have often lost fight of one I have observed with my naked eye; and though, when it was not frighted, I was able to follow the motions of fome with my *Microfcope*; yet if it vere never fo little ftartled, it posted avvay vvith such speed, and turn'd and vvinded it felf fo quick, that I should prefently lose fight of it.

When I first observ'd the former of these Infects, or Mites, I began to conjecture, that certainly I had found out the vagabond Parents of those Mites we find in Cheefes, Meal, Corn, Seeds, musty Barrels, musty Leather, O.c. these little Creatures, vvandring to and fro every vvhither, might perhaps, as they were invited hither and thither by the mufty Iteams of feveral putrifying bodies, make their invafions upon those new and pleafing territories, and there spending the remainder of their life, which might be perhaps a day, or thereabouts, in very plentiful and riotous living, might leave their off-fpring behind them, which by the change of the foil and Country they now inhabite, might be quite alter'd from the hew of their primogenitors, and, like Mores translated into Northern European Climates, after a little time, change both their skin and shape. And this seems yet more probable in these Infects, because that the foil or body they inhabit, feems to be almost half their parent, for it not only hatches and brings those little eggs, or feminal principles, to perfection, but feems to augment and nourish them also before they are hatch'd or shaped; for it is obvious enough to be observ'd, that the eggs of many other Infects, and particularly of Mites, are increas'd in bulk after they are laid out of the bodies of the Infects, and plump'd fometimes into many times their former bignefs, fo that the bodies they are laid in being, as it were, half their mothers, we shall not wonder that it should have fuch an active power to change their forms. We find by relations,

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Now, though I propound this as probable, I have not yet been to farr certify'd by Obfervations as to conclude any thing, either positively or negatively, concerning it. Perhaps, some more lucky diligence may pleafe the curious Inquirer with the difcovery of this, to be a truth, which I now conjecture, and may thereby give him a fatisfactory account of the caufe of those creatures, whose original feems yet to obscure, and may give him caufe to believe, that many other animate beings, that feem allo to be the mere product of putrifaction, may be innobled with a Pedigree as ancient as the first creation, and farr exceed the greatest beings in their numerous Genealogies. But on the other fide, if it sould be found that these, or any other animate body, have no immediate fimilar Parent, I have in another place fet down a conjectural Hypothesis whereby those Phanomena may likely enough be folv'd, wherein the infinite wildom and providence of the Creator is no less rare and wonderfull.

Observ. L I. Of the Crab-like Infect.

TOD I SHOW I I THORSON SOF TON STR

in all the other visible parts i.e.

Eading one day in Septemb. I chanced to observe a very smal creature Creep over the Bock I was reading, very flowly ; having a Microfcope by me,I observ'd it to be a creature of a very unusual form, and that not lefs notable ; fuch as is defcrib'd in the fecond Figure of the 33. Scheme. It was about the bigness of a large Mite, or somewhat longer, it had ten legs, eight of which, AAAA, were topt with veryfharp claws, and were those upon which he walk'd, feeming fhap'd much like those of a Crab, which in many other things also this little creature refembled; for the two other claws, BB, which were the formost of all the ten, and seem'd to grow out of his head, like the horns of other Animals, were exactly form'd in the manner of Crabs or Lobsters claws, for they were shap'd and jointed much like those represented in the scheme and the ends of them were furnish'd with a pair of claws or pincers, CC, which this little animal did open and fhut at pleafure : It feem'd to make use of those two horns or claws both for feelers and holders; for in its motion it carried these aloft extended before, moving them to and fro, just as a man blindfolded would do his hands when he is fearfull of running against a wall, and if I put a hair to it, it would readily take hold of it with these claws, and feem to hold it faft. Now, though these horns seem'd to serve him for two uses, namely, for feeling and holding ; yet he seem'd neither blind, having two fmall black fpots, D D, which by the make of them, and the bright reflection from them feem'd to be his eyes; nor did it want other hands, having another pair of claws, EE, very neer plac'd to its mouth, and feem'd adjoining to it. The whole body was cafed over with armour-fhells, as is usuall in all thole

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thofe kinds of *cruftaceous* creatures, efpecially about their bellies, and feem'd of three kinds; the head F feem'd cover'd with a kind of fealy fhell, the *thorax* with two fmooth fhells, or Rings, G G, and the belly with eight knobb'd ones. I could not certainly find whether it had under thefe laft fhells any wings, but I fufpect the contrary; for I have not found any wing'd Infect with eight leggs, two of thofe leggs being always converted into wings, and, for the moft part, thofe that have but fix, have wings.

This creature, though I could never meet with more then one of them, and fo could not make fo many examinations of it as otherwife I would,Idid notwithftanding,by reafon of the great curiofity that appear'd to me in its fhape, delineate it, to fhew that, in all likelihood, Nature had crouded together into this very minute Infect, as many, and as excellent contrivances, as into the body of a very large Crab, which exceeds it in bulk,perhaps,fome Millions of times; for as to all the apparent parts, there is a greater rather then a lefs multiplicity of parts, each legg has as many parts, and as many joints as a Crabs, nay, and as many hairs or brifles; and the like may be in all the other vifible parts; and 'tis very likely,that the internal curiofities are not lefs excellent : It being a general rule in Nature's proceedings, that where fhe begins to difplay any excellency, if the fubject be further fearch'd into, it will manifeft, that there is not lefs curiofity in those parts which our fingle eye cannot reach, then in those which are more obvious.

Observ. L 1 I. Of the small Silver-colour'd Book-worm.

S among greater Animals there are many that are scaled, both for I ornament and defence, fo are there not wanting fuch also among the leffer bodies of Infects, whereof this little creature gives us an Inftance. It is a fmall white Silver-fhining Worm or Moth, which I found much converfant among Books and Papers, and is fuppos'd to be that which corrodes and eats holes through the leaves and covers; it appears to the naked eye, afmall gliftering Pearl-colour'd Moth, which upon the removing of Books and Papers in the Summer, is often obferv'd very nimbly to fcud, and pack away to fome lurking cranney, where it may the better protect it felf from any appearing dangers. Its head appears bigg and blunt, and its body tapers from it towads the tail, smaller and smaller, being fhap'd almost like a Carret. This the Microfcopical appearance will more plainly manifest, which exhibits, in the third Figure of the 33. Scheme, a conical body, divided into fourteen feveral partitions, being the appearance of fo many feveral shels, or shields that cover the whole body, every of these shells are again cover'd or tiled over with a multitude of thin transparent scales, which, from the multiplicity of their reflecting furfaces, make the whole Animal appear of a perfect Pearl-colour.

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Which, by the way, may hint us the reason of that fo much admired appearance of those so highly efteem'd bodies, as also of the like in mother of Pearl-fhells, and in multitudes of other fhelly Sea-fubftances; for they each of them confifting of an infinite number of very thin shells or laminated orbiculations, caufe fuch multitudes of reflections, that the compolitions of them together with the reflections of others that are fo thin as to afford colours (of which I elsewhere give the reason) gives a very pleafant reflection of light. And that this is the true caufe, feems likely, first, because all those so appearing bodies are compounded of multitudes of plated substances. And next that, by ordering any trasparent substance after this manner, the like Phanomena may be produc'd ; this will be made very obvious by the blowing of Glass into exceeding thin shells, and then breaking them into fcales, which any lamp-worker will prefently do; for a goodquantity of these scales, laid in a heap together, have much the fame refemblance of Pearls. Another way, not lefs inftructive and pleafant, is a way which I have feveral times done, which is by working and toffing, as 'twere, a parcel of pure crystalline glass whilst it is kept glowing hot in the blown flame of a Lamp, for by that means, that purely transparent body will be fo divided into an infinite number of plates, or fmall ftrings, with interpos'd aerial plates and fibres, that from the multiplicity of the reflections from each of those internal furfaces, it may be drawn out into curious Pearl-like or Silver wire, which though fmall, will yet be opacous'; the fame thing I have done with a composition of red Colophon and Turpentine, and a little Bee's Wax, and may be done likewife with Birdlime, and fuch like glutinous and transparent bodies : But to return to our description.

The fmall blunt head of this Infect was furnish'd on either fide of it with a clufter of eyes, each of which feem'd to contain but a very few, in comparison of what I had observ'd the clusters of other Insects to abound with ; each of these clusters were beset with a row of small brifles, much like the cilia or hairs on the eye-lids, and, perhaps, they ferv'd for the fame purpofe. It had two long horns before, which were ftreight, and tapering towards the top, curioufly ring'd or knobb'd, and brifled much like the Marsh Weed, call'd Horse-tail, or Cats-tail, having at each knot a fring'd Girdle, as I may fo call it, of fmaller hairs, and feveral bigger and larger brifles, here and there difpers'd among them ; befides thefe, it had two shorter horns, or feelers, which were knotted and fring'd, just as the former, but wanted brifles, and were blunt at the ends; the hinder part of the creature was terminated with three tails, in every particular refembling the two longer horns that grew out of the head : The leggs of it were scal'd and hair'd much like the rest, but are not express'd in this Figure, the Moth being intangled all in Glew, and fo the leggs of this appear'd not through the Glass which looked perpendicularly upon the back. This Animal probably feeds upon the Paper and covers of Books, and perforates in them feveral small round holes, finding, perhaps, a convenient nourishment in those husks of Hemp and Flax, which have pass'd through Ff

through fo many fcourings, washings, dreffings and dryings, as the parts of old Paper must necessarily have suffer'd; the digestive faculty, it seems, of these little creatures being able yet surther to work upon those stubborn parts, and reduce them into another form.

And indeed, when I confider what a heap of Saw-duft or chips this little creature (which is one of the teeth of Time) conveys into its intrals. I cannot chufe but remember and admire the excellent contrivance of Nature, in placing in Animals fuch a fire, as is continually nourifhed and fupply'd by the materials convey'd into the ftomach, and *fomented* by the bellows of the lungs; and in fo contriving the moft admirable fabrick of Animals, as to make the very fpending and wafting of that fire, to be inftrumental to the procuring and collecting more materials to augment and cherifh it felf, which indeed feems to be the principal end of all the contrivances obfervable in bruit Animals.

Observ. LIII. Of a Flea.

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THe strength and beauty of this small creature, had it no other relation at all to man, would deferve a description.

For its strength, the Microscope is able to make no greater discoveries of it then the naked eye, but onely the curious contrivance of its leggs and joints, for the exerting that strength, is very plainly manifested, such as no other creature, I have yet observ'd, has any thing like it; for the joints of it are fo adapted, that he can, as 'twere, fold them fhort one within another, and fuddenly ftretch, or fpring them out to their whole length, that is, of the fore-leggs, the part A, of the 34. Scheme, lies within B, and B within C, parallel to, or fide by fide each other; but the parts of the two next, lie quite contrary, that is, D without E, and E without F, but parallel alfo; but the parts of the hinder leggs, G, H and I, bend one within another, like the parts of a double jointed Ruler, or like the foot, legg and thigh of a man; these fix leggs he clitches up altogether, and when he leaps, fprings them all out, and thereby exerts his whole strength at once. But, as for the beauty of it, the Microscope manifest it to be all over adorn'd with a curioully polifh'd fuit of fable Armour, neatly jointed, and befet with multitudes of fharp pinns, fhap'd almost like Porcupine's Quills, or bright conical Steel-bodkins; the head is on either fide beautify'd with a quick and round black eye K, behind each of which alfo appears a small cavity, L, in which he seems to move to and fro a certain thin film befet with many fmall transparent hairs, which probably may be his ears; in the forepart of his head, between the two fore-leggs, he has two small long jointed feelers, or rather smellers, M M, which have four joints, and are hairy, like those of several other creatures ; between these, it has a small proboscis, or probe, NNO, that seems to consist of a tube,

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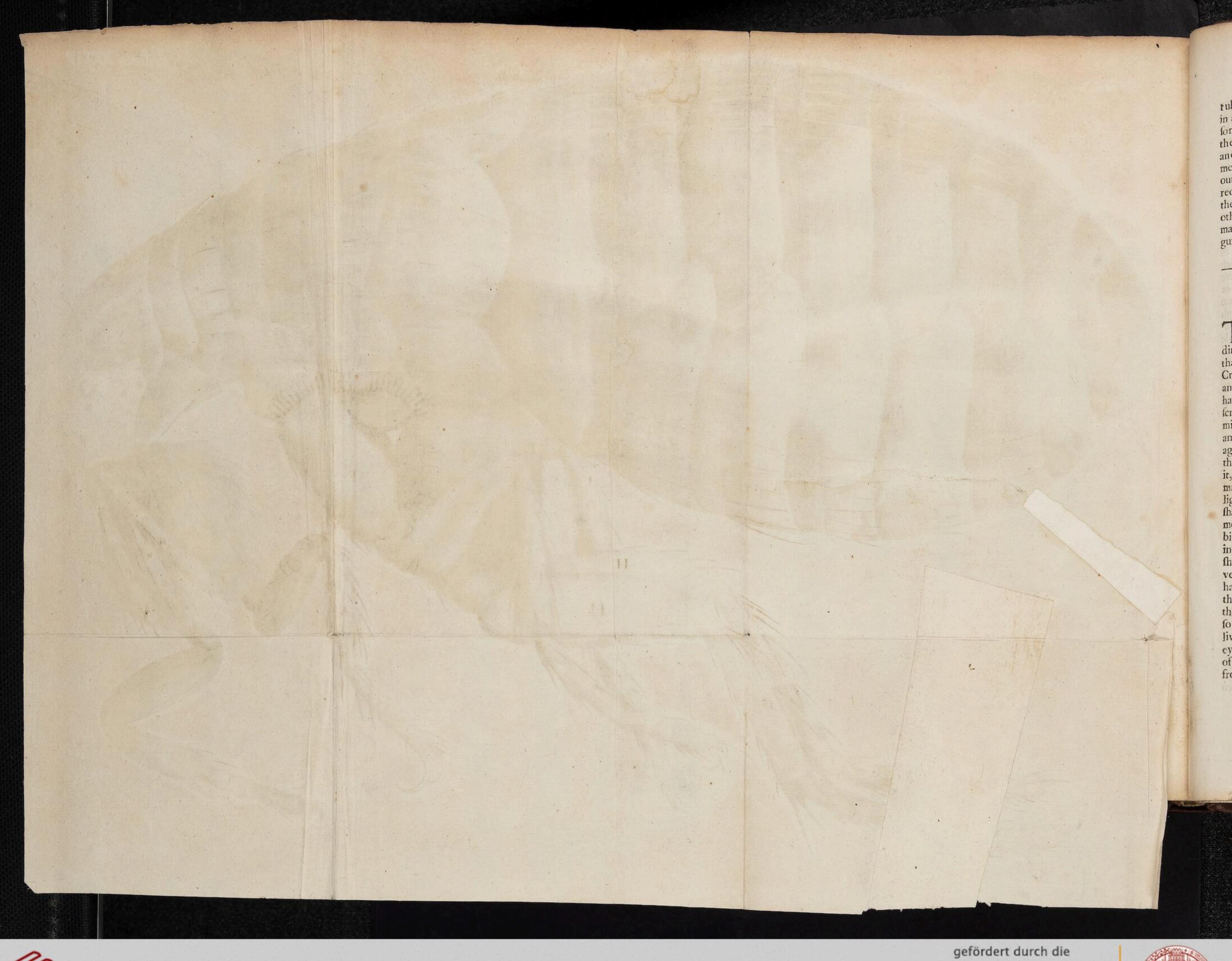
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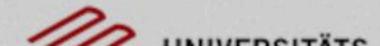
overies s leggs d, fuch for the with-ength, hin B, e parts with-and I, ler, or up al-exerts

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tube N N, and a tongue or fucker O, which I have perceiv'd him to flip in and out. Befides these, it has also two chaps or biters PP, which are fomewhat like those of an Ant, but I could not perceive them tooth'd; these were shap'd very like the blades of a pair of round top'd Scizers, and were opened and fhut just after the fame manner ; with these Instruments does this little busie Creature bite and pierce the skin, and suck out the blood of an Animal, leaving the fkin inflamed with a fmall round red spot. These parts are very difficult to be discovered, because, for the most part, they lye covered between the fore-legs. There are many other particulars, which, being more obvious, and affording no great matter of information, I shall pass by, and refer the Reader to the Figure.

Observ. LIV. Of a Louse.

His is a Creature fo officious, that 'twill be known to every one at one time or other, fo busie, and so impudent, that it will be intruding it felf in every ones company, and fo proud and afpiring withall, that it fears not to trample on the beft, and affects nothing fo much as a Crown; feeds and lives very high, and that makes it fo faucy, as to pull any one by the cars that comes in its way, and will never be quiet till it has drawn blood: it is troubled at nothing fo much as at a man that fcratches his head, as knowing that man is plotting and contriving fome mischief against it, and that makes it oftentime sculk into some meaner and lower place, and run behind a mans back, though it go very much against the hair; which ill conditions of it having made it better known then trufted, would exempt me from making any further defcription of it, did not my faithful Mercury, my Microscope, bring me other information of it. For this has discovered to me, by means of a very bright light caft on it, that it is a Creature of a very odd shape ; it has a head shap'd like that exprest in 35. Scheme marked with A, which seems almost Conical, but is a little flatted on the upper and under fides, at the biggeft part of which, on either fide behind the head (as it were, being the place where other Creatures ears stand) are placed its two black fhining goggle eyes BB, looking backwards, and fenced round with feveral small cilia or hairs that incompass it, so that it feems this Creature has no very good forefight: It does not feem to have any eye-lids, and therefore perhaps its eyes were fo placed, that it might the better cleanfe them with its fore-legs; and perhaps this may be the reason, why they fo much avoid and run from the light behind them, for being made to live in the fhady and dark receffes of the hair, and thence probably their eye having a great aperture, the open and clear light, especially that of the Sun, must needs very much offend them; to fecure these eyes from receiving any injury from the hairs through which it paffes, it has Ff 2

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two horns that grow before it, in the place where one would have thought the eyes should be; each of these CC hath four joynts, which are fringed, as 'twere, with small brifles, from which to the tip of its fnout D, the head feems very round and tapering, ending in a very sharp nose D, which seems to have a small hole, and to be the passage through which he fucks the blood. Now whereas if it be plac'd on its back, with its belly upwards, as it is in the 35. Scheme, it feems in feveral Positions to have a refemblance of chaps, or jaws, as is represented in the Figure by EE, yet in other postures those dark strokes disappear ; and having kept feveral of them in a box for two or three dayes, fo that for all that time they had nothing to feed on, I found, upon letting one creep on my hand, that it immediately fell to fucking, and did neither feem to thrust its nose very deep into the skin, nor to open any kind of mouth, but I could plainly perceive a small current of blood, which came directly from its fnout, and paft into its belly; and about A there feem'd a contrivance, fomewhat refembling a Pump, pair of Bellows, or Heart, for by a very fwift stole and diastole the blood feem'd drawn from the nofe, and forced into the body. It did not feem at all, though I viewed it a good while as it was fucking, to thrust more of its nose into the skin then the very fnout D, nor did it cause the least discernable pain, and yet the blood feem'd to run through its head very quick and freely, so that it seems there is no part of the skin but the blood is difpers'd into, nay, even into the cuticula; for had it thrust its whole nose in from D to CC, it would not have amounted to the supposed thicknefs of that tegument, the length of the nofe being not more then a three hundredth part of an inch. It has fix legs, covered with a very transparent shell, and joynted exactly like a Crab's, or Lobster's; each leg is divided into fix parts by these joynts, and those have here and there feveral small hairs; and at the end of each leg it has two claws, very properly adapted for its peculiar ufe, being thereby inabled to walk very fecurely both on the fkin and hair; and indeed this contrivance of the feet is very curious, and could not be made more commodioufly and compendioully, for performing both these requisite motions, of walking and climbing up the hair of a mans head, then it is : for, by having the leffer claw (a) fet so much short of the bigger (b) when it walks on the fkin the fhorter touches not, and then the feet are the fame with those of a Mite, and several other small Infects, but by means of the fmall joynts of the longer claw it can bend it round, and fo with both claws take hold of a hair, in the manner represented in the Figure, the long transparent Cylinder FFF, being a Man's hair held by it. The Thorax feem'd cas'd with another kind of fubftance then the belly, namely, with a thin transparent horny substance, which upon the fasting of the Creature did not grow flaccid; through this I could plainly fee the blood, fuck'd from my hand, to be varioully distributed, and mov'd to and fro; and about G there feem'd a pretty big white fubftance, which feem'd to be moved within its thorax; befides, there appear'd very many fmall milk-white veffels, which croft over the breaft between

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between the legs, out of which, on either fide, were many fmall branchings, these feem d to be the veins and arteries, for that which is analogus to blood in all Infects is milk-white.

The belly is covered with a transparent substance likewife, but more refembling a fkin then a shell, for 'tis grain'd all over the belly just like the skin in the palms of a man's hand, and when the belly is empty, grows very flaccid and wrinkled 3 at the upper end of this is placed the ftomach HH, and perhaps also the white spot II may be the liver or pancreas, which by the periftaltick motion of the guts, is a little mov'd to and fro, not with a systele and diastele, but rather with a thronging or justling motion. Viewing one of these Creatures, after it had fasted two dayes, all the hinder part was lank and flaccid, and the white fpot I I hardly mov'd, most of the white branchings disappear'd, and most also of the redness or fucked blood in the guts, the periftaltick motion of which was fcarce difcernable; but upon the fuffering it to fuck, it prefently fill'd the fkin of the belly, and of the fix fcolop'd embofments on either fide, as full as it could be stuft ; the stomach and guts were as full as they could hold; the periftaltick motion of the gut grew quick, and the justling motion of II accordingly; multitudes of milk-white veffels feem'd quickly filled, and turgid, which were perhaps the veins and arteries, and the Creature was fo greedy, that though it could not contain more, yet it continued fucking as fast as ever, and as fast emptying it felf behind : the digestion of this Creature must needs be very quick, for though I perceiv'd the blood thicker and blacker when fuck d, yet, when in the guts, it was of a very lovely ruby colour, and that part of it, which was digefted into the veins, feemed white; whence it appears, that a further digeftion of blood may make it milk, at least of a refembling colour : What is elfe observable in the figure of this Creature, may be feen by the 35. Scheme.

Observ. LV. Of Mites.

The leaft of *Reptiles* I have hitherto met with, is a Mite, a Creature whereof there are fome fo very fmall, that the fharpeft fight, unaffifted with Glaffes, is not able to dilcern them, though, being white of themfelves, they move on a black and fmooth furface; and the Eggs, out of which these Creatures feem to be hatch'd, are yet fmaller, those being ufually not above a four or five hundredth part of a well grown Mite, and those well grown Mites not much above one hundredth of an inch in thickness; fo that according to this reckoning there may be no less then a million of well grown Mites contain'd in a cubick inch, and five hundred times as many Eggs.

Notwithstanding which minuteness a good Microscope discovers those small movable specks to be very prettily shap'd Insects, each of them furnish'd

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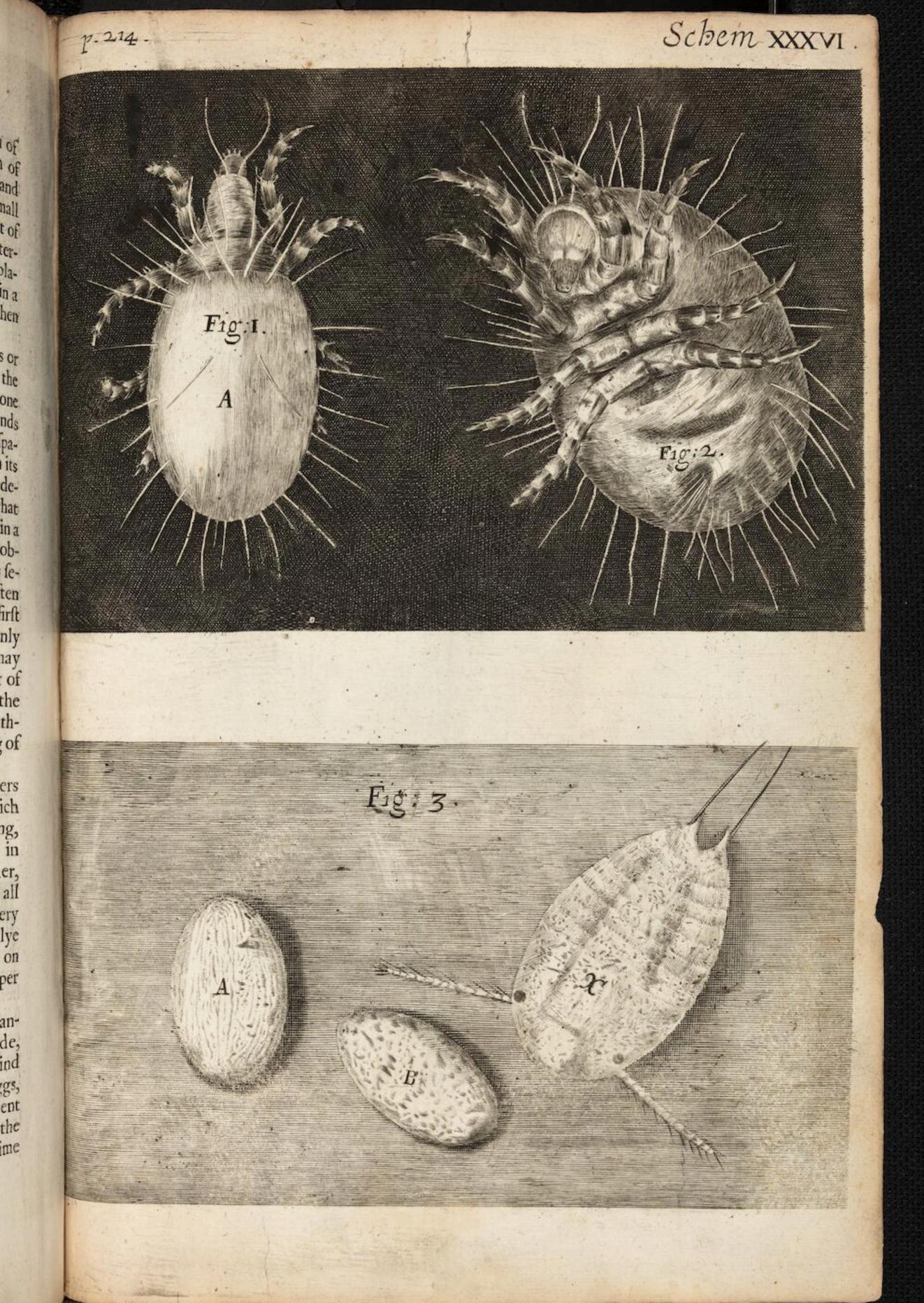
nifh'd with eight well fhap'd and proportion'd legs, which are each of them joynted or bendable in eight feveral places, or joynts, each of which is covered, for the most part, with a very transparent shell, and the lower end of the shell of each joynt is fringed with feveral small hairs; the contrivance of the joynts seems the very same with that of Crabs and Lobsters legs, and like those also, they are each of them terminated with a very sharp claw or point; four of these legs are so placed, that they seem to draw forwards, the other four are placed in a quite contrary position, thereby to keep the body backwards when there is occasion.

Fig. 1. Schem, 36,

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The body, as in other larger Infects, confifts of three regions or parts; the hinder or belly A, feems covered with one intire shell, the middle, or cheft, feems divided into two fhells B C. which running one within the other, the Mite is able to fhrink in and thrust out as it finds occasion, as it can also the snout D. The whole body is pretty transparent, fo that being look'd on against the light, divers motions within its body may be perceived ; as also all the parts are much more plainly delineable, then in other poftures, to the light. The shell, especially that which covers the back, is curioufly polifht, fo that 'tis eafie to fee, as in a convex | Looking-glass, or foliated Glass-ball, the picture of all the objects round about; up and down, in feveral parts of its body, it has feveral small long white hairs growing out of its shell, which are often longer then the whole body, and are represented too fhort in the first and fecond Figures; they feem all pretty ftraight and plyable, fave only two upon the fore-part of its body, which feem to be the horns, as may be seen in the Figures; the first whereof is a prospect of a smaller fort of Mites (which are usually more plump) as it was paffant to and fro; the fecond is the profpect of one fixt on its tail (by means of a little mouthglew rub'd on the object plate) exhibiting the manner of the growing of the legs, together with their feveral joynts.

This Creature is very much diversify'd in shape, colour, and divers other properties, according to the nature of the substance out of which it feems to be ingendred and nourifhed, being in one fubftance more long, in another more round, in fome more hairy, in others more fmooth, in this nimble, in that flow, here pale and whiter, there browner, blacker, more transparent, O.c. I have observed it to be refident almost on all kinds of fubstances that are mouldy, or putrifying, and have seen it very nimbly melhing through the thickets of mould, and fometimes to lye dormant underneath them; and 'tis not unlikely, but that it may feed on that vegetating substance, fontaneous Vegetables seeming a food proper enough for spontaneous Animals, But whether indeed this Creature, or any other, be fuch or not, I cannot politively, from any Experiment, or Observation, I have yet made, determine. But, as I formerly hinted, it feems probable, that fome kind of wandring Mite may fow, as 'twere, the first feeds, or lay the first eggs, in those places, which Nature has instructed them to know convenient for the hatching and nourishing their young ; and though perhaps the prime



prime Parent might be of a fhape very differing from what the offfpring, after a little while, by reafon of the fubfrance they feed on, or the Region (as 'twere) they inhabite; yet perhaps even one of thefe alter'd progeny, wandering again from its native foil, and lighting on by chance the fame place from whence its prime Parent came, and there fettling, and planting, may produce a generation of Mites of the fame fhapes and properties with the firft wandring Mite: And from fome fuch accidents as thefe, I am very apt to think, the most forts of Animals, generally accounted *fpontaneous*, have their origination, and all those various forts of Mites, that are to be met with up and down in divers putrifying fubfrances, may perhaps be all of the fame kind, and have fprung from one and the fame fort of Mites at the first.

Observ. LVI. Of a small Creature hatch'd on a Vine.

or parent lafeet, that has layd that? Even a for havin

Here is, almost all the Spring and Summer time, a certain small; round, white Cobweb, as 'twere, about the bigness of a Pea, which fticks very close and fast to the stocks of Vines nayl'd against a warm wall : being attentively viewed, they feem cover'd, upon the upper fide of them, with a fmall husk, not unlike the fcale, or fhell of a Woodloufe, or Hog-loufe, a small Infect usually found about rotten wood, which upon touching prefently rouls it felf into the form of a peppercorn: Separating feveral of these from the stock, I found them, with my Microscope, to confift of a shell, which now seemed more likely to be the hufk of one of these Infects: And the fur feem'd a kind of cobweb, confifting of abundance of fmall filaments, or fleaves of cobwebs. In the midft of this, if they were not hatch'd, and run away before, the time of which hatching was ufually about the latter end of June, or beginning of July, I have often found abundance of fmall brown Eggs, fuch as A and B in the fecond Figure of the 36. Scheme, much about the bignefs of Mites Eggs; and at other times, multitudes of fmall Infects, fhaped exactly like that in the third Figure marked with X. Its head large, almost half the bigness of its body, which is usual in the fatus of most Creatures. It had two fmall black eyes a a, and two fmall long joynted and brilled horns b b. The hinder part of its body feem'd to confift of nine scales, and the last ended in a forked tayl, much like that of a Cutio, or Wood loufe, out of which grew two long hairs; they ran to and fro very swiftly, and were much of the bigness of a common Mite, but some of them less: The longest of them seem'd not the hundredth part of an inch, and the Eggs usually not above half as much. They feemed to have fix legs, which were not visible in this I have here delineated, by reason they were drawn under its body. If these Minute creatures were Wood-lice (as indeed from their own shape and frame, the fkin, or fhell, that grows on them, one may with great probability 190716

bability ghefs) it affords us an Infrance, whereof perhaps there are not many like in Nature, and that is, of the prodigious increase of these Creatures, after they are hatch'd and run about for a common Wood-loufe, of about half an inch long, is no less then a hundred and twenty five thoufand times bigger then one of these, which though indeed it seems very strange, yet I have observed the young ones of some Spiders have almost kept the same proportion to their Dam.

This, methinks, if it be fo, does in the next place hint a Quæry, which may perhaps deferve a little further examination : And that is, Whether there be not many of those minute Creatures, fuch as Mites, and the like, which, though they are commonly thought of otherwise, are only the *pully*, or young ones, of much bigger Infects, and not the generating, or parent Infect, that has layd those Eggs; for having many times obferv'd those Eggs, which usually are found in great abundance where Mites are found, it feems fomething strange, that fo small an Animal should have an Egg fo big in proportion to its body. Though on the other fide, I must confess, that having kept divers of those Mites inclosed in a box for a good while, I did not find them very much augmented beyond their usual bigness.

What the husk and cobweb of this little white fubftance fhould be, I cannot imagine, unlefs it be, that the old one, when impregnated with Eggs, fhould there ftay, and fix it felf on the Vine, and dye, and all the body by degrees fhould rot, fave only the husk, and the Eggs in the body : And the heat, or fire, as it were, of the approaching Sun-beams fhould vivifie those Relicts of the corrupted Parent, and out of the afhes, as 'twere, (as it is fabled of the *Phænix*) fhould raife a new off-fpring for the perpetuation of the *fpecies*. Nor will the cobweb, as it were, in which these Eggs are inclos'd, make much against this Conjecture; for we may, by those cobwebs that are carried up and down the Air after a Fog (which with my *Microscope* I have discovered to be made up of an infinite company of fmall filaments or threads) learn, that fuch a texture of body may be otherwise made then by the spinning of a Worm.

about propo tail, C Tak fmall F plate, almoft Eal or Ith prever nious, that a Viol, in a vo And motio plain, wavin and th fenfib wond no fal ficies city a the or the m fmall Air, v ter,th rymi bigge fuch : it had

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Observ. LVII. Of the Eels in Vinegar.

OF these small Eels, which are to be found in divers forts of Vinegar, I have little to add besides their Picture, which you may find drawn in the third Figure of the 25. *scheme*: That is, they were shaped much like an Eel, fave only that their nose A, (which was a little more opacous then the rest of their body) was a little sharper, and longer, in proportion to their body, and the wrigling motion of their body seem'd to be onely upwards and downwards, whereas that of Eels is onely side wayes: They seem'd to have a more opacous part about

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about B, which might, perhaps, be their Gills; it feeming always the fame proportionate diftant from their nofe, from which, to the tip of their tail, C, their body feem'd to taper.

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Taking feveral of these out of their Pond of Vinegar, by the net of a fmall piece of filtring Paper, and laying them on a black smooth Glass plate, I found that they could wriggle and winde their body, as much almost as a Snake, which made me doubt, whether they were a kind of Eal or Leech.

I fhall add no other obfervations made on this minute Animal, being prevented herein by many excellent ones already publish'd by the ingenious, Doctor *Power*, among his *Microscopical* Observations, fave onely that a quantity of Vinegar repleat with them being included in a small Viol, and stop'd very close from the ambient air, all the included Worms in a very short time died, as if they had been stifled.

And that their motion feems (contrary to what we may obferve in the motion of all other Infects) exceeding flow. But the reafon of it feems plain, for being to move to and fro after that manner which they do, by waving onely, or wrigling their body; the tenacity, or glutinousnes, and the denfity or refiftance of the fluid medium becomes fo exceeding fenfible to their extremely minute bodies, that it is to me indeed a greater wonder that they move them fo fast as they do, then that they move them no faster. For what a vastly greater proportion have they of their superficies to their bulk, then Eels or other larger Fishes, and next, the tenacity and denfity of the liquor being much the fame to be moved, both by the one and the other, the refiftance or impediment thence arifing to the motions made through it, must be almost infinitely greater to the fmall one then to the great. This we find experimentally verify'd in the Air, which though a medium a thousand times more rarify'd then the water, the refiftance of it to motions made through it, is yet fo fenfible to very minute bodies, that a Down-feather (the least of whole parts feem yet bigger then these Eels, and many of them almost incomparably bigger, fuch as the quill and stalk) is suspended by it, and carried to and fro as if it had no weight.

Observ. LVIII. Of a new Property in the Air, and several other transparent Mediums nam'd Inflection, whereby very many confiderable Phænomena are attempted to be solv'd, and divers other uses are binted.

Since the Invention (and perfecting in fome measure) of *Telescopes*, it has been observed by several, that the Sun and Moon neer the Horizon, are disfigured (losing that exactly-smooth terminating circular limb, which they are observed to have when situated neerer the Zenith) and are bounded with an edge every way (especially upon the right and left G g fides)

fides) ragged and indented like a Saw : which inequality of their limbs, I have further observed, not to remain always the same, but to be continually chang'd by a kind of fluctuating motion, not unlike that of the waves of the Sca; fo as that part of the limb, which was but even now nick'd or indented in, is now protuberant, and will prefently be finking again ; neither is this all, but the whole body of the Luminaries, do in the Telescope, seem to be depress'd and flatted, the upper, and more especially the under fide appearing neerer to the middle then really they are, and the right and left appearing more remote: whence the whole Area feems to be terminated by a kind of Oval.It is further observ'd, that the body, for the most part, appears red, or of some colour approaching neer unto it, as fome kind of yellow; and this I have always mark d, that the more the limb is flatted or ovalled, the more red does the body appear, though not always the contrary. It is further observable, that both fix'd Stars and Planets, the neerer they appear to the Horizon, the more red and dull they look, and the more they are observ'd to twinkle; in fo much, that I have feen the Dog-ftarr to vibrate fo ftrong and bright a radiation of light, as almost to dazle my eyes, and prefently, almost to disappear. It is also observable, that those bright scintillations neer the Horizon, are not by much fo quick and fudden in their confecutions of one another, as the nimbler twinklings of Stars neerer the Zenith. This is also notable, that the Starrs neer the Horizon, are twinkled with feveral colours; fo as fometimes to appear red, fometimes more yellow, and fometimes blue, and this when the Starr is a pretty way elevated above the Horizon. I have further, very often seen some of the small Starrs of the fifth or fixth magnitude, at certain times to difappear for a fmall moment of time, and again appear more confpicuous, and with a greater lufter. I have feveral times, with my naked eye, feen many fmaller Starrs, fuch as may be call'd of the feventh or eighth magnitude to appear for a fhort space, and then vanish, which, by directing a small Telescope towards that part they appear'd and difappeard in; I could prefently find to be indeed fmall Starrs fo fituate, as I had feen them with my naked eye, and to appear twinkling like the ordinary visible Stars; nay, in examining some very notable parts of the Heaven, with a three foot Tube, me thought I now and then, in feveral parts of the conftellation, could perceive little twinklings of Starrs, making a very fhort kind of apparition, and prefently vanishing, but noting diligently the places where they thus feem'd to play at boepeep, I made use of a very good twelve foot Tube, and with that it was not uneafie to fee those, and foveral other degrees of smaller Starrs, and fome smaller yet, that seem'd again to appear and disappear, and these alfo by giving the fame Object-glafs a much bigger aperture, I could plainly and conftantly fee appear in their former places; fo that I have observ'd some twelve several magnitudes of Starrs less then those of the fix magnitudes commonly recounted in the Globes. It has been observ'd and confirm'd by the accuratest Observations of the best of our modern Astronomers, that all the Luminous bodies appear above the Horizon, when they really are below it. So that the Sun Sun and has bee that the have 3 then it Ihav and his Trees, tice of at a go **fpicuot** tremul Divers have g gether true,b Phanon the fev in mak and fe caufe the tr plicate and th superfie within Fir vario thefe caufe. Sec conft diver By that (upon Icall then perpe that] So then ' theat 30:0 but 4 Wine

Sun and Moon have both been feen above the Horizon, whil's the Moon has been in an Eclipfe. I shall not here instance in the great refractions, that the tops of high mountains, feen at a distance, have been found to have ; all which feem to argue the Horizontal refraction, much greater then it is hitherto generally believ'd.

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I have further taken notice, that not onely the Sun, Moon and Starrs, and high tops of mountains have fuffer'd these kinds of refraction, but Trees, and feveral bright Objects on the ground : I have often taken notice of the twinkling of the reflections of the Sun from a Glafs-window at a good diftance, and of a Candle in the night, but that is not fo confpicuous, and in observing the setting Sun, I have often taken notice of the tremulation of the Trees and Bufhes, as well as of the edges of the Sun. Divers of these Phanomena have been taken notice of by feveral, who have given feveral reafons of them, but I have not yet met with any altogether fatisfactory, though some of their conjectures have been partly true, but parly also false. Setting my felf therfore upon the inquiry of these Phanomena, I first endeavour'd to be very diligent in taking notice of the feveral particulars and circumstances observable in them; and next, in making divers particular Experiments, that might cleer fome doubts, and ferve to determine, confirm, and illustrate the true and adæquate caufe of each ; and upon the whole, I find much reafon to think, that the true caufe of all these Phanomena is from the inflection, or multiplicate refraction of those Rays of light within the body of the Atmosphere, and that it does not proceed from a refraction caus'd by any terminating superficies of the Air above, nor from any fuch exactly defin'd superficies within the body of the Atmosphere.

This Conclusion is grounded upon these two Propositions:

First, that a medium, whose parts are unequally dense, and mov'd by various motions and transpositions as to one another, will produce all these visible effects upon the Rays of light, without any other coefficient cause.

Secondly, that there is in the Air or Atmosphere, fuch a variety in the constituent parts of it, both as to their density and rarity, and as to their divers mutations and positions are to their other and rarity and rarity.

divers mutations and politions one to another.

By Density and Rarity, I understand a property of a transparent body, that does either more or less refract a Ray of light (coming obliquely upon its superficies out of a third medium) toward its perpendicular : As I call Glass a more dense body then Water, and Water a more rare body then Glass, because of the refractions (more or less deflecting towards the perpendicular) that are made in them, of a Ray of light out of the Air that has the same inclination upon either of their superficies.

So as to the bufinels of Refraction, spirit of Wine is a more *dense* body then Water, it having been found by an accurate Instrument that measures the angles of Refractions to Minutes that for the same refracted angle of 30:00' in both those *Mediums*, the angle of incidence in Water was but 41°. 3'5. but the angle of the incidence in the trial with spirit of Wine was $42^\circ: 45'$. But as to gravity, Water is a more *dense* body then G g 2 fpirit

spirit of Wine, for the proportion of the same Water, to the same very well rectify'd spirit of Wine was, as 21. to 19.

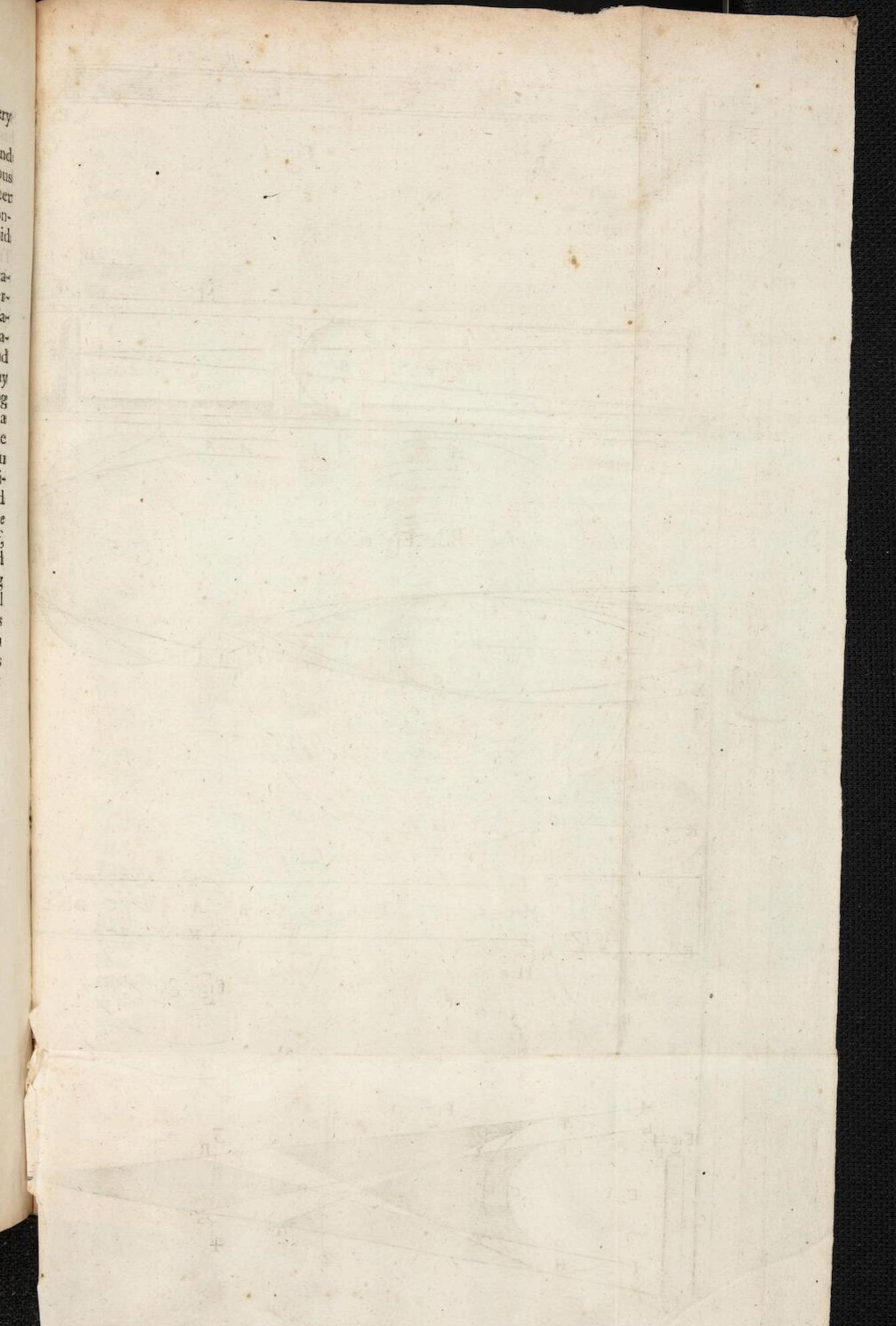
So as to Refraction, Water is more Denfe then Ice; for I have found by a most certain Experiment, which I exhibited before divers illustrious Perfons of the *Royal Society*, that the Refraction of Water was greater then that of Ice, though fome confiderable Authors have affirm'd the contrary, and though the Ice be a very hard, and the Water a very fluid body.

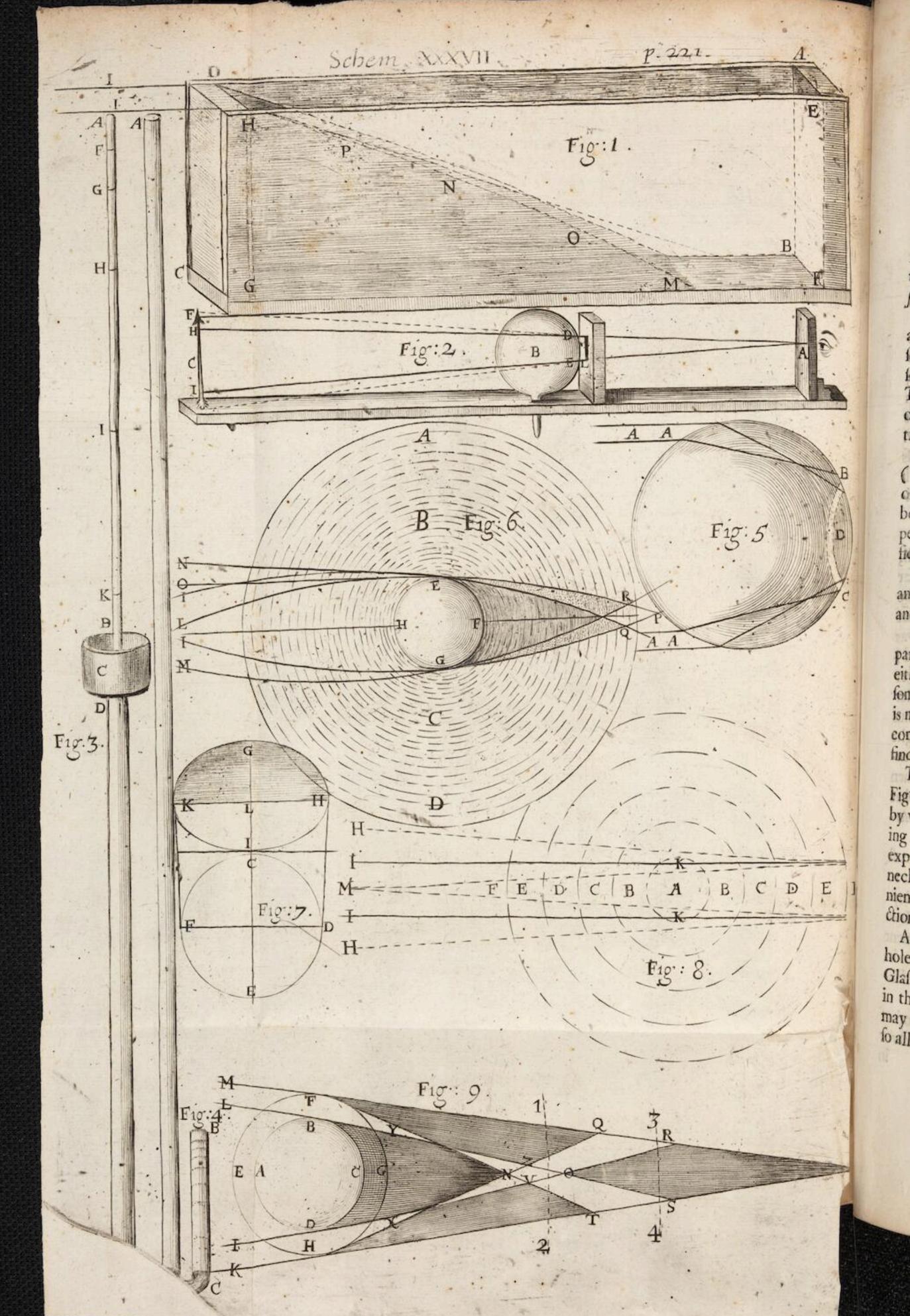
That the former of the two preceding Propositions is true, may be manifested by several Experiments: As first, if you take any two liquors differing from one another in denfity, but yet fuch as will readily mix:as SaltWater, or Brine, & Fresh; almost any kind of Salt dissolv'd in Water, and filtrated, fo that it be cleer, spirit of Wine and Water; nay, spirit of Wine, and spirit of Wine, one more highly rectify'd then the other, and very many other liquors; if(I fay) you take any two of these liquors, and mixing them in a Glafs Viol, against one fide of which you have fix'd or glued a fmall round piece of Paper, and shaking them well together (so that the parts of them may be somewhat diffurb'd and move up and down)you endeavour to fee that round piece of Paper through the body of the liquors; you shall plainly perceive the Figure to wave, and to be indented much after the fame manner as the limb of the Sun through a Telefcope feems to be, fave onely that the mutations here, are much quicker. And if, in fteed of this bigger Circle, you take a very fmall fpot, and faften and view it as the former, you will find it to appear much like the twinkling of the Starrs, though much quicker : which two Phanomena (for I fhall take notice of no more at prefent, though I could inftance in multitudes of others) must necessarily be caused by an inflection of the Rays within the terminating fuperficies of the compounded medium, fince the furfaces of the transparent body through which the Rays pass to the eye, are not at all altered or chang'd.

This inflection (if I may fo call it) I imagine to be nothing elfe, but a multiplicate refraction, caufed by the unequal density of the constituent parts of the medium, whereby the motion, action or progress of the Ray of light is hindred from proceeding in a streight line, and inflected or deflected by a curve. Now, that it is a curve line is manifest by this Experiment : I took a Box, fuch as A D G E, in the first Figure of the 37. Scheme, whofe fides ABCD, and EFGH, were made of two fmooth flat plates of Glass, then filling it half full with a very ftrong folution of Salt, I filled the other half with very fair fresh water, then exposing the opacous fide, DHGC, to the Sun, I observ'd both the refraction and inflection of the Sun beams, ID& KH, and marking as exactly as I could, the points, P, N, O, M, by which the Ray, K H, paffed through the compounded medium, I found them to be in a curve line; for the parts of the medium being continually more denfe the neerer they were to the bottom, the Ray p f was continually more and more deflected downwards from the ftreight line.

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This Inflection may be mechanically explained, either by Monfieur Des





Des Cartes principles, by conceiving the Globuls of the third Element to find lefs and lefs refiftance against that fide of them which is downwards, or by a way, which I have further explicated in the Inquisition about Colours, to be from an obliquation of the pulfe of light, whenee the ruder part is continually promoted, and confequently refracted towards the perpendicular, which cuts the Orbs at night angles. What the particular Figure of the Curve line, described by this way of light, is, I shall not now frand to examine, effectially fince there may be formany forts of it as there may be varieties of the Politions of the intermediat degrees of denfity and rarity between the bottom and the top of the inflecting Medium

I could produce many more Examples and Experiments, to illustrate and prove this first Proposition, viz. that there is such a constitution of fome bodies as will caufe inflection. As not to mention those I have obferv'd in Horn, Tontoise-shell, transparent Gums, and refinous Substances : The veins of Glais, nay, of melted Cryftal, found, and much complained of by Glass-grinders, and others, might sufficiently demonstrate the truth of it to any diligent Obfervator.

But that, I prefume, I have by this Example given proof fufficient (viz. oeular demonstration) to evince, that there is fuch a modulation, or bending of the rayes of light, as I have call'd inflection, differing both from reflection, and refraction (fince they are both made in the fuperficies, this only in the middle); and likewife, that this is able or fufficient to produce the effects I have alcribed to it.

It remains therefore to thew, that there is fuch a property in the Air, and that it is fufficient to produce all the above mentioned Phanomena. and therefore may be the principal, if not the only caufe of them.

First, That there is such a property, may be proved from this, that the parts of the Air are fome of them more condens'd, others more rarified, either by the differing heat, or differing preflure it fuftains, or by the fomewhat heterogeneous vapours interfpers'd through it. For as the Air is more or lefs rarified, fo does it more or lefs refract a ray of light (that comes out of a denfer medium) from the perpendicular. This you may find true, if you make tryal of this Experiment. H SHIE DAGEN

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Take a small Glass-bubble, made in the form of that in the fecond Figure of the 37. Scheme, and by heating the Glafs very hot, and thereby very much rarifying the included Air, or, which is better, by rarifying a small quantity of water, included in it, into vapours, which will expel the most part, if not all the Air, and then fealing up the small neck of it, and letting it cool, you may find, if you place it in a convenient Inftrument, that there will be a manifest difference, as to the refraction.

As if in this fecond Figure you suppose A to represent a small fight or hole, through which the eye looks upon an object, as C, through the Glass-bubble B, and the fecond fight L; all which remain exactly fixt in their feveral places, the object C being fo cized and placed, that it may just feem to touch the upper and under edge of the hole L : and to all of it be feen through the small Glass-ball of rarified Air; then by breaking

breaking off the fmall feal'd neck of the Bubble (without at all ftirring the fights, object, or glafs) and admitting the external Air, you will find your felf unable to fee the utmost ends of the object; but the terminating rayes A E and A D (which were before refracted to G and F by the rarified Air) will proceed almost directly to I and H; which alteration of the rayes (feeing there is no other alteration made in the Organ by which the Experiment is tryed, fave only the admission, or exclusion of the condens'd Air) must necessarily be caused by the variation of the medium contain'd in the Glafs B; the greatest difficulty in the making of which Experiment, is from the uneven surfaces of the bubble, which will represent an uneven image of the object.

Now, that there is fuch a difference of the upper and under parts of the Air, is clear enough evinc'd from the late improvement of the *Torricellian* Experiment, which has been tryed at the tops and feet of Mountains; and may be further illuftrated, and inquired into, by a means, which fome whiles fince I thought of, and us'd, for the finding by what degrees the Air pafles from fuch a degree of Denfity to fuch a degree of Rarity. And another, for the finding what preffure was requifite to make it pafs from fuch a degree of Rarefaction to a determinate Denfity: Which Experiments, becaufe they may be useful to illuftrate the prefent Inquiry, I shall briefly defcribe.

Fig. 3.

I took then a small Glass-pipe A B, about the bigness of a Swans quill, and about four foot long, which was very equally drawn, fo that, as far as I could perceive, no one part was bigger then another: This Tube (being open at both ends) I fitted into another small Tube DE, that had a small bore just big enough to contain the small Pipe, and this was feal'd up at one, and open at the other, end; about which open end I fastned a small wooden box C with cement, so that filling the bigger Tube, and part of the box, with Quickfilver, I could thruft the fmaller Tube into it, till it were all covered with the Quickfilver : Having thus done, I fastned my bigger Tube against the fide of a wall, that it might stand the steadier, and plunging the small Tube cleer under the Mercury in the box, I ftopt the upper end of it very fast with cement, then lifting up the small Tube, I drew it up by a small pully, and a string that I had fastned to the top of the Room, and found the height of the Mercurial Cylinder to be about twenty nine inches. Then letting down the Tube again, I opened the top, and then thrust down the small Tube, till I perceived the Quickfilver to rife within it to a mark that I had plac'd just an inch from the top;and immediately clapping on a small peice of cement that I had kept warm, I with a hot Iron feal'd up the top very fast, then letting it cool (that both the cement might grow hard, and more especially, that the Air might come to its temper, natural for the Day I try'd the Experiment in) I observ'd diligently, and found the included Air to be exactly an Inch.

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Here you are to take notice, that after the Air is feal'd up, the top of the Tube is not to be elevated above the superficies of the Quickfilver in

in the box, till the furface of that within the Tube be equal to it, for the Quickfilver (as I have elfewhere prov'd) being more heterogeneous to the Glafs then the Air, will not naturally rife up to high within the fmall Pipe, as the fuperficies of the *Mercury* in the box; and therefore you are to obferve, how much below the outward fuperficies of the *Mercury* in the box, that of the fame in the Tube does ftand, when the top being open, free ingr. is is admitted to the outward Air.

Having thus done, I permitted the Cylinder, or fmall Pipe, to rife out of the box, till I found the furface of the Quickfilver in the Pipe to be two inches above that in the box, and found the Air to have expanded it felf but one fixteenth part of an inch; then drawing up the finall pipe, till I found the height of the Quickfilver within to be four inches above that without, I observed the Air to be expanded only 1 of an inch more then it was at first, and to take up the room of 17 inch: then I raifed the Tube till the Cylinder was fix inches high, and found the Air to take up 13 inches of room in the Pipe; then to 8, 10, 12. Oc. the expansion of the Air that I found to each of which Cylinders are fet down in the following Table; where the first row fignifies the height of the Mercurial Cylinder; the next, the expansion of the Air; the third, the preffure of the Atmosphere, or the highest Cylinder of Mercury, which was then neer thirty inches : The last fignifies the force of the Air fo expanded, which is found by fubstracting the first row of numbers out of the third; for having found, that the outward Air would then keep up the Quickfilver to thirty inches, look whatever of that height is wanting must be attributed to the Elater of the Air depressing. And therefore having the Expansion in the fecond row, and the height of the fubjacent Cylinder of Mercury in the first, and the greatest height of the Cylinder of Mercury, which of it felf counterballances the whole preffure of the Atmosphere; by fubftracting the numbers of the first row out of the numbers of the third, you will have the measure of the Cylinders fo deprest, and consequently the force of the Air, in the several Expanfions, registred. OF

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The height of the Cylinder of Mer- cury, that, together with the Elater of the included Air, ballanced the preffure of the	fion of the Air.	The height of the Mercury that counter- ballanc'd the Atmosphere	of the Elater of the expan-
Atmosphere.	1000		pipes and line solo
00	OI	30	30
02	01 ¹ / ₁₆	30	28
04	$OI\frac{1}{7}$	30	26
06	OI 2	30	24
08	OI	30	22
IO	OI	30	20
12	OI	30	18
14	OIS	30	16
16	021	30	14
18	024	30	potro I2 lodi
20	03	- 30	10
22	037	30	8
24	057	30	6
25	06-2	30	5
. 26	081	30	4
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thefes. But ten m perim part o fignific mosphe and t ons of cury 5 inches found 26_{4}^{1-} 26_{4}^{3-} 27103 31 31 3 30 30 30 13 15¦ 'I'lie height

I had feveral other Tables of my Observations, and Calculations, which I then made; but it being above a twelve month fince I made them; and by that means having forgot many circumstances and particulars, I was refolved to make them over once again, which I did August the second 1661. with the very same Tube which I used the year before, when I first made the Experiment (for it being a very good one, I had carefully preferv'd it :) And after having tryed it over and over again; and being not well fatisfied of fome particulars, I, at laft, having put all things in very good order, and being as attentive, and observant, as possibly I could, of every circumstance requisite to be taken notice of, did register my several Observations in this following Table. In the making of which, I did not exactly follow the method that I had used at first; but, having lately heard of Mr. Townly's Hypothesis, I shap'd my course in such fort, as would be most convenient for the examination of that Hypothesis; the event of which you have in the latter part of the last Table.

The other Experiment was, to find what degrees of force were requifite to comprefs, or condenfe, the Air into fuch or fuch a bulk.

The manner of proceeding therein was this: I took a Tube about five foot long, one of whole ends was fealed up, and bended in the form of a *syphon*, much like that represented in the fourth Figure of the 37. *Scheme*, one fide whereof AD, that was open at A, was about fifty inches long, the other fide BC, flut at B, was not much above feven inches long; then placing it exactly perpendicular, I pour'd in a little Quickfilver, and found that the Air BC was $6\frac{1}{2}$ inches, or very near to feven; then pouring in Quickfilver at the longer Tube, I continued filling of it till the Air in the florter part of it was contracted into half the former dimensions, and found the height exactly nine and twenty inches; and by making feveral other tryals, in feveral other degrees of condensation of the Air, I found them exactly answer the former Hypothefis.

But having (by reafon it was a good while fince I first made) forgotten many particulars, and being much unfatisfied in others. I made the Experiment over again, and, from the feveral tryals, collected the former part of the following Table : Where in the row next the left hand 24. fignifies the dimensions of the Air, fustaining only the pressure of the Atmosphere, which at that time was equal to a Cylinder of Mercury of nine and twenty inches: The next Figure above it (20) was the dimensions of the Air induring the first compression, made by a Cylinder of Mercury 5⁺, high, to which the pressure of the Atmosphere nine and twenty inches being added, the elastick strength of the Air so compress will be found 34^{+}_{16} , Cc.

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A Table of the Elastick power of the Air, both Experimentally and Hypothetically calculated, according to its various Dimensions.

Fund Structure and an and the line of the state						
The dimen-	The height	The Mercu-	The fum	Whatthey		
fions of the	of the Mer-	rial Cylinder	or diffe-	ought to		
included	curial Cylin-	added, or	rence of	be accor-		
Air.	der counter-	taken from				
1111.	pois'd by	the former.	Cylinders.	the Hypo-		
	the Atmo-	1	neominoq 2	thesis.		
		parties of an	in a marine	Inter establi		
inter ada, 14	sphere.	I Transport	tigada protecti	inetion out		
10	20	29=	58	58		
12	29 +		The state of the second second	and a subscription of the		
13	29 +	24 ¹¹ =	537	537		
14	29 t	2016	49.6	497		
16	29 t	14==	43 .	43:-		
18	29 +	9==	385	38;		
20	29 t	5:6=	3416	34.		
. 24	29	0=	29 :	29		
48	29-	14 <u>5</u> =	143	14 ^r / ₂		
96	29-	22	67.	7:		
and all a state of the state of the			Contraction and a second	35		
192	20-	255=	37	28		



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From which Experiments, I think, we may fafely conclude, that the Elater of the Air is reciprocal to its extension, or at least very neer. So that to apply it to our prefent purpose (which was indeed the chief caufe of inventing these wayes of tryal) we will suppose a Cylinder indefinitely extended upwards, [I fay a Cylinder; not a piece of a Cone, because, as I may elsewhere shew in the Explication of Gravity, that triplicate proportion of the shels of a Sphere, to their respective diameters, I suppose to be removed in this case by the decrease of the power of Gravity] and the preffure of the Air at the bottom of this Cylinder to be strong enough to keep up a Cylinder of Mercury of thirty inches : Now because by the most accurate tryals of the most illustrious and incomparable Mr. Boyle, published in his defervedly famous Pneumatick Book, the weight of Quickfilver, to that of the Air here below, is found neer about as fourteen thousand to one: If we suppose the parts of the Cylinder of the Atmosphere to be every where of an equal density, we shall (as he there deduces) find it extended to the height of thirty five thousand feet, or seven miles: But because by these Experiments we have fomewhat confirm'd the hypothesis of the reciprocal proportion of the Elaters to the Extensions we shall find, that by supposing this Cylinder of the Atmosphere divided into a thousand parts, each of which being equivalent to thirty five feet, or feven geometrical paces, that is, each of these divisions containing as much Air as is suppos'd in a Cylinder neer the earth of equal diameter, and thirty five foot high, we shall find the lowermost to prefs against the furface of the Earth with the whole weight of the above mentioned thousand parts; the preffure of the bottom of the fecond against the top of the first to be 1000-1=999. of the third against the fecond to be $1000_2 = 998$. of the fourth against the third to be 1000 - 3 = 997. of the uppermost against the 999. or that next below it, to be $1000-999 \equiv 1$. fo that the extension of the lowermost next the Earth, will be to the extension of the next below the uppermost, as 1. to 999. for as the preflure suffained by the 999. is to the preflure fuftain'd by the first, so is the extension of the first to the extension of the 999. fo that, from this hypothetical calculation, we shall find the Air to be indefinitely extended : For if we suppose the whole thickness of the Air to be divided, as I just now instanced, into a thoufand parts, and each of those under differing Dimensions, or Altitudes, to contain an equall quantity of Air, we shall find, that the first Cylinder, whofe Bafe is fuppofed to lean on the Earth, will be found to be extended 353999 foot; the second equal Division, or Cylinder, whose basis is fupposed to lean on the top of the first, shall have its top extended higher by 3570; the third 35997; the fourth 35996; and fo onward, each equal quantity of Air having its dimensions measured by 35. and some additional number exprest alwayes in the manner of a fraction, whose numerator is alway the number of the place multipli'd by 35. and whose denominator is alwayes the pressure of the Atmosphere suffain'd by that part, fo that by this means we may eafily calculate the height of 999. divisions of those 1000. divisions, I suppos'd; whereas the uppermost Hh 2 may

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may extend it felf more then as high again, nay, perhaps indefinitely, or beyond the Moon; for the Elaters and Expansions being in reciprocal proportions, fince we cannot yet find the *plus ultra*, beyond which the Air will not expand it felf, we cannot determine the height of the Air: for fince, as we have shewn, the proportion will be alway as the preffure fustain'd by any part is to 35. fo 1000. to the expansion of that part; the multiplication or product therefore of the preffure, and expansion, that is, of the two extream proportionals, being alwayes equal to the product of the means, or 35000. it follows, fince that Rectangle or Product may be made up of the multiplication of infinite diversifies of numbers, that the height of the Air is also indefinite; for fince (as far as I have yet been able to try) the Air feems capable of an indefinite Expansion, the preflure may be decreased in *infinitum*, and confequently its expansion upwards indefinite also.

There being therefore fuch a difference of denfity, and no Experiment yet known to prove a *saltus*, or fkipping from one degree of rarity to another much differing from it, that is, that an upper part of the Air fhould fo much differ from that immediately *fubjacent* to it, as to make a diffinct fuperficies, fuch as we obferve between the Air and Wamake a diffinct fuperficies, fuch as we obferve between the Air and Water, \mathfrak{Gc} . But it being more likely, that there is a continual increase of rarity in the parts of the Air, the further they are removed from the furface of the Earth: It will hence neceffarily follow, that (as in the Experiment of the falt and fresh Water) the ray of Light passing obliquely through the Air also, which is of very different density, will be continually, and infinitely inflected, or bended, from a ftreight, or direct motion.

This granted, the reafon of all the above recited *Phanomena*, concerning the appearance of the Celeftial Bodies, will very eafily be deduced. As,

First, The redness of the Sun, Moon, and Stars, will be found to be caufed by the inflection of the rays within the Atmosphere. That it is not really in or near the luminous bodies, will, I suppose, be very easily granted, seeing that this redness is observable in several places differing in Longitude, to be at the same time different, the setting and rising Sun of all parts being for the most part red : And fecondly, That it is not meerly the colour of the Air interpos'd, will, I suppose, without much more difficulty be yielded, seeing that we may observe a very great interstitium of Air betwixt the Object and the Eye, makes it appear of a dead blew, far enough differing from a red, or yellow. But thirdly, That it proceeds from the refraction, or inflection, of the rays by the Atmosphere, this following Experiment will, I suppose, sufficiently manifest. Take a sphærical Crystalline Viol, such as is describ'd in the fifth Figure ABCD, and, having fill'd it with pure clear Water, expose it to the Sun beams; then taking a piece of very fine Venice Paper, apply it against that side of the Globe that is opposite to the Sun, as against the

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fide BC, and you mail perceive a bright red Ring to appear, caus'd by the refraction of the Rays, A A A A, which is made by the Globe; in which Experiment, if the Glass and Water be very cleer, fo that there be no Sands nor bubbles in the Glafs, nor dirt in the Water, you shall not perceive any appearance of any other colour. To apply which Experiment, we may imagine the Atmosphere to be a great transparent Globe, which being of a fubstance more dense then the other, or (which comes to the fame) that has its parts more denfe towards the middle, the Sun beams that are tangents, or next within the tangents of this Globe, will be refracted or inflected from their direct passage towards the center of the Globe, whence, according to the laws of refractions made in a triangular Prism, and the generation of colour fet down in the description of Muscovi-glass, there must necessarily appear a red colour in the transitus or passage of those tangent Rays. To make this more plain, we will suppose (in the fixth Figure) ABCD, to represent the Globe of the Atmosphere, EFGH to represent the opacous Globe of the Earth, lying in the midft of it, neer to which, the parts of the Air, fustaining a very great preflure, are thereby very much condens'd, from whence those Rays that are by inflection made tangents to the Globe of the Earth, and those without them, that pass through the more condens'd part of the Atmosphere, as suppose between A and E, are by reason of the inequality of the medium, inflected towards the center, whereby there must neceffarily be generated a red colour, as is more plainly thewn in the former cited place; hence whatfoever opacous bodies (as vapours, or the like) fhall chance to be elevated into those parts, will reflect a red towards the eye; and therefore those evenings and mornings appear reddest, that have the most store of vapours and halituous substances exhaled to a convenient diftance from the Earth; for thereby the inflection is made the greater, and thereby the colour alfo the more intenfe; and feveral of those exhalations being opacous, reflect feveral of those Rays, which, through an Homogeneons transparent medium would pass unfeen; and therefore we fee, that when there chances to be any clouds fituated in those Regions they reflect a ftrong and vivid red. Now, though one great caufe of the rednefs may be this inflection, yet I cannot wholly exclude the colour of the vapours themfelves, which may have fomething of rednefs in them, they being partly nitrous, and partly fuliginous; both which freams tinge the Rays that pass through them, as is made evident by looking at bodies through the fumes of Aqua fortis, or spirit of Nitre [as the newly mentioned Illustrious Person has demonstrated] and also through the smoak of a Fire or Chimney.

Having therefore made it probable at least, that the morning and evening redness may partly proceed from this inflection or refraction of the Rays, we shall next shew, how the Oval Figure will be likewise easily deduced.

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Suppose we therefore, EFGH in the fixth Figure of the 37. Scheme, to represent the Earth; ABCD, the Atmospere; EI, and EL, two Rays coming from the Sun, the one from the upper, the other from the neather Limb,

Limb, these Rays, being by the Atmosphere inflected, appear to the eye at E, as if they had come from the points, N and O; and because the Ray L has a greater inclination upon the inequality of the Atmosphere then I, therefore must it fuffer a greater inflection, and consequently be further elevated above its true place, then the Ray I, which has a lefs inclination, will be elevated above its true place; whence it will follow, that the lower fide appearing neerer the upper then really it is, and the two lateral fides, viz. the right and left fide, fuffering no fensible alteration from the inflection, at least what it does fuffer, does rather increase the visible Diameter then diminish it, as I shall show by and by, the Figure of the luminous body must necessarily appear somewhat Elliptical.

This will be more plain, if in the feventh Figure of th 37. Scheme we suppose AB to represent the sensible Horizon; CDEF, the body of the Sun really below it; GHIK, the fame appearing above it, elevated by the inflection of the Atmosphere : For if, according to the best observation, we make the visible Diameter of the Sun to be about three or four and thirty minutes, and the Horizontal refraction according to Ticko be thereabout, or fomewhat more, the lower limb of the Sun E, will be elevated to I; but becaufe, by his account, the point C will be elevated but 29. minutes, as having not fo great an inclination upon the inequality of the Air, therefore IG, which will be the apparent refracted perpendicular Diameter of the Sun, will be lefs then C G, which is but 29. minutes, and confequently fix or feven minutes fhorter then the unrefracted apparent Diameter. The parts, D and F, will be likewife elevated to H and K. whole refraction, by reason of its inclination, will be bigger then that of the point C, though lefs then that of E; therefore will the femidiameter IL, be fhorter then L G, and confequently the under fide of the appearing Sun more flat then the upper.

Now, becaufe the Rays from the right and left fides of the Sun, &c. have been observ'd by Ricciolo and Grimaldus, to appear more distant one from another then really they are, though (by very manyObservations that I have made for that purpole, with a very good Telescope, fitted with a divided Ruler) I could never perceive any great alteration, yet there being really fome, it will not be amifs, to fhew that this also proceeds from the refraction or inflection of the Atmosphere; and this will be manifest, if we confider the Atmosphere as a transparent Globe, or at least a transparent fhell, encompafiing an opacous Globe, which, being more denfe then the medium encompassing it, refracts or inflects all the entring parallel Rays into a point or focus, so that wherefoever the Observator is plac'd within the Atmosphere, between the focus and the luminous body, the lateral Rays must necessarily be more converg'd towards his eye by the refraction or inflection, then they would have been without it; and therefore the Horizontal Diameter of the luminous body must necessarily be augmented.

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This might be more plainly manifest to the eye by the fixth Figure ; but because it would be somewhat tedious, and the thing being obvious enough

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enough to be imagin'd by any one that attentively confiders it, I fhall rather omit it, and proceed to fhew, that the mafs of Air neer the furface of theEarth,confifts,or is made up,of parcels,which do very much differ from one another in point of denfity and rarity ; and confequently the Rays of light that pafs through them will be varioufly inflected, here one way, and there another, according as they pafs fo or fo through those differing parts; and those parts being always in motion, either upwards or downwards, or to the right or left, or in fome way compounded of these, they do by this their motion inflect the Rays, now this way, and prefently that way.

This irregular, unequal and unconftant inflection of the Rays of light, is the reafon why the limb of the *Sun*, *Moon*, *Jupiter*, *Saturn*, *Mars*, and *Venus*, appear to wave or dance; and why the body of the Starrs appear to tremulate or twinkle, their bodies, by this means, being fometimes magnify'd, and fometimes diminifhed; fometimes elevated, otherwhiles deprefs'd; now thrown to the right hand, and then to the left.

And that there is fuch a property or unequal distribution of parts, is manifest from the various degrees of heat and cold that are found in the Air; from whence will follow a differing denfity and rarity, both as to quantity and refraction; and likewife from the vapours that are interpos'd, (which, by the way, I imagine, as to refraction or inflection, to do the fame thing, as if they were rarify'd Air; and that those vapours that afcend, are both lighter, and lefs denfe, then the ambient Air which boys them up; and that those which descend, are heavier and more dense) The first of these may be found true, if you take a good thick piece of Glafs, and heating it pretty hot in the fire, lay it upon fuch another piece of Glafs, or hang it in the open Air by a piece of Wire, then looking upon some far distant Object (such as a Steeple or Tree) so as the Rays from that Object pass directly over the Glass before they enter your eye, you shall find such a tremulation and wavering of the remote Object, as will very much offend your eye: The like tremulous motion you may observe to be caus'd by the ascending steams of Water, and the like. Now, from the first of these it is manifest, that from the rarifaction of the parts of the Air, by heat, there is caus'd a differing refraction, and from the ascension of the more rarify'd parts of the Air, which are thrust up by the colder, and therefore more condens'd and heavie, is caus'd an undulation or wavering of the Object; for I think, that there are very few will grant, that Glafs, by as gentle a heat as may be endur'd by ones hand, should fend forth any of its parts in steams or vapours, which does not feem to be much wafted by that violent fire of the green Glafs-houfe; but, if yet it be doubted, let Experiment be further made with that body that is accounted, by Chymifts and others, the most ponderous and fix'd in the world; for by heating of a piece of Gold, and proceeding in the fame manner, you may find the fame effects. This trembling and shaking of the Rays, is more sensibly caus'd by an actual flame, or quick fire, or any thing elfe heated glowing hot; as by a Candle, live Coal, red-hot Iron, or a piece of Silver, and the like : the fame also appears very conspicuous, if you look at an Object betwixt which

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which and your eye, the rifing fmoak of fome Chimney is interpos'd; which brings into my mind what I had once the opportunity to obferve, which was, the Sun rifing to my eye juft over a Chimney that fent forth a copious fteam of fmoak; and taking a fhort *Telefcope*, which I had then by me, I obferv d the body of the Sun, though it was but juft peep d above the Horizon, to have its underfide, not onely flatted, and prefs'd inward, as it ufually is when neer the Earth; but to appear more protuberant downwards then if it had fuffered no refraction at all; and befides all this, the whole body of the Sun appear'd to tremble or dance, and the edges or limb to be very ragged or indented, undulating or waving, much in the manner of a flag in the Wind.

This I have likewife often obferv'd in a hot Sunfhiny Summer's day, that looking on an Object over a hot ftone, or dry hot earth, I have found the Object to be undulated or fhaken, much after the fame manner. And if you look upon any remote Object through a *Telefcope* (in a hot Summer's day efpecially) you fhall find it likewife to appear tremulous. And further, if there chance to blow any wind, or that the air between you and the Object be in a motion or current, whereby the parts of it, both rarify'd and condens'd, are fwiftly remov'd towards the right or left, if then you obferve the Horizontal ridge of a Hill far diftant, through a very good *Telefcope*, you fhall find it to wave much like the Sea, and thofe waves will appear to pafs the fame way with the wind.

From which, and many other Experiments, tis cleer that the lower Region of the Air, effectially that part of it which lieth neereft to the Earth, has, for the most part, its constituent parcels varioully agitated, either by heat or winds, by the first of which, some of them are made more rare, and so fuffer a less refraction; others are interwoven, either with ascending or descending vapours; the former of which being more light, and so more rarify'd, have likewife a less refraction; the latter being more heavie, and consequently more dense, have a greater.

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Now, becaufe that heat and cold are equally diffus'd every way; and that the further it is fpread, the weaker it grows; hence it will follow, that the most part of the under Region of the Air will be made up of several kinds of lentes, fome whereof will have the properties of Convex, others of Concave glass; which, that I may the more intelligibly make out, we will suppose in the eighth Figure of the 37. scheme, that A reprefents an alcending vapour, which, by reafon of its being fomewhat Heterogeneous to the ambient Air, is thereby thrust into a kind of Globular form, not any where terminated, but gradually finished, that is, it is most rarity'd in the middle about A, fomewhat more condens'd about B B, more then that about CC; yet further, about DD, almost of the fame denfity with the ambient Air about EE; and laftly, inclofed with the more dense Air F F, so that from A, to FF, there is a continual increafe of denfity. The reafon of which will be manifelt, if we confider the riting vapour to be much warmer then the ambient heavie Air; for by the coldness of the ambient Air, the shell E E will be more refrigerated then D D, and that then CC, which will be yet more then B B, and that more

more then A; fo that from F to A, there is a continual increase of heat, and consequently of rarity; from whence it will necessarily follow, that the Rays of light will be inflected or refracted in it, in the same manner as they would be in a *Concave-glase*; for the Rays GKI, GKI will be inflected by GKH, GKH, which will easily follow from what I before explained concerning the inflection of the *Atmosphere*.

On the other fide, a descending vapour, or any part of the air included by an afcending vapour, will exhibit the fame effects with a Convex lens ; for, if we suppose, in the former Figure, the quite contrary constitution to that last describ'd; that is, the ambient Air F F being hotter then any part of that matter within any circle, therefore the coldeft part must necessarily be A, as being fartheft remov'd from the heat, all the intermediate spaces will be gradually discriminated by the continuall mixture of heat and cold, fo that it will be hotter at EE, then DD, in DD then CC, in CC then BB, and in BB then A. From which, a like refraction and condenfation will follow; and confequently a leffer or greater refraction, fo that every included part will refract more then the including, by which means the Rays, GKI, GKI, coming from a Starr, or fome remote Object, are fo inflected, that they will again concurr and meet, in the point M. By the interpolition therefore of this defcending vapour the visible body of the Star, or other Object, is very much augmented, as by the former it was diminished.

From the quick confecutions of thefe two, one after another, between the Object and your eye, caufed by their motion upwards or downwards, proceeding from their levity or gravity, or to the right or left, proceeding from the wind, a Starr may appear, now bigger, now lefs, then really it would otherwife without them; and this is that property of a Starr, which is commonly call'd twinkling, or fcintillation.

The reafon why a Star will now appear of one colour, now of another, which for the moft part happens when 'tis neer the Horizon, may very eafily be deduc'd from its appearing now in the middle of the vapour, other whiles neer the edge; for if you look againft the body of a Starr with a *Telefcope* that has a pretty deep *Convex* Eye-glafs, and fo order it, that the Star may appear fometimes in one place, and fometimes in another of it; you may perceive this or that particular colour to be predominant in the apparent Figure of the Starr, according as it is more or lefs remote from the middle of the *Lens*. This I had here further explain'd, but that it does more properly belong to another place.

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I shall therefore onely add some few Quæries, which the confideration of these particulars hinted, and so finish this Section.

And the first I shall propound is, Whether there may not be made an artificial transparent body of an exact Globular Figure that shall so inflect or refract all the Rays, that, coming from one point, fall upon any *Hemisphere* of it; that every one of them may meet on the opposite fide, and cross one another exactly in a point; and that it may do the like also with all the Rays that, coming from a *lateral* point, fall upon any other *Hemisphere*; for if so, there were to be hoped a perfection of *Dioptricks*, I i

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and a transmigration into heaven, even whil'st we remain here upon earth in the flefh, and a defcending or penetrating into the center and innermost recesses of the earth, and all earthly bodies; nay, it would open not onely a cranney, but a large window (as I may fo fpeak) into the Shop of Nature, whereby we might be enabled to fee both the tools and operators, and the very manner of the operation it felf of Nature; this, could it be effected, would as farr furpals all other kind of perspectives as the vast extent of Heaven does the imall point of the Earth, which distance it would immediately remove, and unite them, as 'twere, into one, at leaft, that there should appear no more distance between them then the length of the Tube, into the ends of which these Glasses should be mserted: Now, whether this may not be effected with parcels of Glass of feveral denfities, I have fometimes proceeded fo farr as to doubt (though in truth, as to the general, 1 have wholly defpair'd of it) for I have often observ'd in Optical Glasses a very great variety of the parts, which are commonly called Veins; nay, fome of them round enough (for they are for the most part, drawn out into strings) to constitute a kind of lens.

This I fhould further proceed to ope, had any one been fo inquifitive as to have found out the way of making any transparent body, either more dense or more rare; for then it might be possible to compose a Globule that should be more dense in the middle of it, then in any other part, and to compose the whole bulk, so as that there should be a continual gradual transition from one degree of density to another; such as should be found requisite for the desired inflection of the transmigrating Rays; but of this enough at present, because I may fay more of it when I set down my own Trials concerning the melioration of Dioptricks, where I shall enumerate with how many several substances I have made both Microscopes, and Telescopes, and by what and how many, ways: Let fuch as have leisure and opportunity farther consider it.

The next Quæry shall be, whether by the same collection of a more dense body then the other, or at least, of the denser part of the other, there might not be imagin'd a reason of the apparition of some new fix'd Stars, as those in the Swan, Cassion Charr, Serpentarius, Piscis, Cetus, &c.

Thirdly, Whether it be poffible to define the height of the Atmosphere

fecol out, defc Jar S ritio red,l quite 5. this Suppo are, tothe webs No may I rimen Ma of for poyle Wate it to withc perim and c the m 6. after for I c an ad which found in the factio. true ; and co could tore c Way I poys' link, 1 Cand then f and the were This Air, then t

from this inflection of the Rays, or from the Quickfilver Experiment of the rarifaction or extension of the Air.

Fourthly, Whether the difparity between the upper and under Air be not fometimes fo great, as to make a reflecting fuperficies; I have had feveral Obfervations which feem to have proceeded from fome fuch caufe, but it would be too long to relate and examine them. An Experiment, alfo fomewhat analogous to this, I have made with Salt-water and Frefh, which two liquors, in moft Pofitions, feem'd the fame, and not to be feparated by any determinate fuperficies, which feparating furface yet in fome other Pofitions did plainly appear.

And if fo, Whether the reafon of the equal bounding or terminus of the under parts of the clouds may not proceed from this caufe ; whether, fecondly,

fecondly, the Reafon of the apparition of many Suns may not be found out, by confidering how the Rays of the Sun may fo be reflected, as to defcribe a pretty true Image of the body, as we find them from any regu-Iar Superficies. Whether alfo this may not be found to caufe the apparition of fome of those *Parelii*, or counterfeit Suns, which appear coloured, by refracting the Rays fo, as to make the body of the Sun appear in quite another place then really it is. But of this more elfewhere.

5. Whether the *Phænomena* of the Clouds may not be made out by this diverfity of denfity in the upper and under parts of the Air, by fuppofing the Air above them to be much lighter then they themfelves are, and they themfelves to be yet lighter then that which is fubjacent to them, many of them feeming to be the fame fubftance with the Cobwebs that fly in the Air after a Fog.

Now that fuch a conftitution of the Air and Clouds, if fuch there be, may be fufficient to perform this effect, may be confirm'd by this Experiment.

Make as ftrong a Solution of Salt as you are able, then filling a Glafs of fome depth half full with it, fill the other half with frefh Water, and poyfe a little Glafs-bubble, fo as that it may fink pretty quick in frefh Water, which take and put into the aforefaid Glafs, and you fhall find it to fink till it comes towards the middle, where it will remain fixt, without moving either upwards or downwards. And by a fecond Experiment, of poifing fuch a bubble in water, whofe upper part is warmer, and confequently lighter, then the under, which is colder and heavier ; the manner of which follows in this next Quæry, which is,

6. Whether the rarifaction and condensation of Water be not made after the fame manner, as those effects are produc'd in the Air by heat; for I once pois'd a feal'd up Glass-bubble fo exactly, that never fo small an addition would make it fink, and as fmall a detraction make it fwim, which fuffering to reft in that Veffel of Water for fome time, I alwayes found it about noon to be at the bottom of the Water, and at night, and in the morning, at the top: Imagining this to proceed from the Rarifaction of the Water, caus'd by the heat, I made tryal, and found most true; for I was able at any time, either to deprefs, or raife it, by heat and cold; for if I let the Pipe stand for some time in cold water, I could eafily raife the Bubble from the bottom, whither I had a little afore detruded it, by putting the fame Pipe into warm Water. And this way I have been able, for a very confiderable time, to keep a Bubble fo poys'd in the Water, as that it fhould remain in the middle, and neither fink, nor fwim: For gently heating the upper part of the Pipe with a Candle, Coal, or hot Iron, till I perceived the Bubble begin to defcend, then forbearing, I have observed it to descend to such or such a station, and there to remain fuspended for fome hours, till the heat by degrees were quite vanished, when it would again ascend to its former place. This I have also often observed naturally performed by the heat of the Air, which being able to rarifie the upper parts of the Water fooner then the lower, by reason of its immediate contact, the heat of the Air has has Ii 2

has fometimes fo flowly increased, that I have observed the Bubble to be fome hours in passing between the top and bottom.

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7. Whether the appearance of the Pike of Tenerif, and feveral other high Mountains, at fo much greater a diftance then feems to agree with their respective heights, be not to be attributed to the Curvature of the vifual Ray, that is made by its paffing obliquely through fo differingly Dense a Medium from the top to the eye very far distant in the Horizon : For fince we have already, I hope, made it very probable, that there is fuch an inflection of the Rays by the differing denfity of the parts of the Air; and fince I have found, by feveral Experiments made on places comparatively not very high, and have yet found the prefiure fuftain'd by those parts of the Air at the top and bottom, and also their differing Expansions very confiderable : Infomuch that I have found the prefiure of the Atmosphere lighter at the top of St. Paul's Steeple in London (which is about two hundred foot high) then at the bottom by a fixtieth or fiftieth part, and the expansion at the top greater then that at the bottom by neer about fo much alfo; for the Mercurial Cylinder at the bottom was about 39. inches, and at the top half an inch lower; the Air also included in the Weather-glass, that at the bottom fill d only 155. spaces, at the top fill'd 158. though the heat at the top and bottom was found exactly the fame with a fcal'd Thermometer: I think it very rational to suppose, that the greatest Curvature of the Rays is made nearest the Earth, and that the inflection of the Rays, above 3. or 4. miles upwards, is very inconfiderable, and therefore that by this means fuch calculations of the height of Mountains, as are made from the diftance they are visible in the Horizon, from the supposal that that Ray is a straight Line (that from the top of the Mountain is, as'twere, a Tangent to the Horizon whence it is feen) which really is a Curve, is very erroneous. Whence, I fuppofe, proceeds the reafon of the exceedingly differing Opinions and Affertions of feveral Authors, about the height of feveral very high Hills.

8. Whether this Inflection of the Air will not very much alter the fupposed distances of the Planets, which seem to have a very great dependence upon the Hypothetical refraction or inflection of the Air, and that refraction upon the hypothetical height and denfity of the Air: For fince (as I hope) I have here fhewn the Air to be quite otherwife then has been hitherto suppos'd, by manifesting it to be, both of a vast, at leaft an uncertain, height, and of an unconftant and irregular denfity; It must necessarily follow, that its inflection must be varied accordingly : And therefore we may hence learn, upon what fure grounds all the Aftronomers hitherto have built, who have calculated the diftance of the Planets from their Horizontal Parallax; for fince the Refraction and Parallax are fo nearly ally'd, that the one cannot be known without the other, especially by any wayes that have been yet attempted, how uncertain must the Parallax be, when the Refraction is unknown? And how easie is it for Aftronomers to affign what diftance they pleafe to the Planets, and defend them, when they have fuch a curious fubterfuge as that of Refraction, wherein a very little variation will allow them liberty enough to place the Celestial Bodies at what distance they please. K

oth tiv find enc tw(bei mu per. att and kinį each the fuch orl Plan ters thei actl con St. I tot Geo they beir cult the A mad Ifur fit a Obf that vati The ftan be t ferv Plan cult fame bot and outi mov repe

If therefore we would come to any certainty in this point, we must go other wayes to work ; and as I have here examined the height and refractive property of the Air by other wayes then are ufual, fo must we find the Parallax of the Planets by wayes not yet practifed ; and to this end, I cannot imagine any better way, then the Observations of them by two perfons at very far diftant parts of the Earth, that lye as neer as may be under the fame Meridian, or Degree of longitude, but differing as much in latitude, as there can be places conveniently found : Thefe two perfons, at certain appointed times, should (as near as could be) both at the fame time, observe the way of the Moon, Mars, Venus, Jupiter, and Saturn, amongst the fixt Stars, with a good large Telescope, and making little Iconilmes, or pictures, of the small fixed Stars, that appear to each of them to lye in or near the way of the Center of the Planet, and the exact measure of the apparent Diameter; from the comparing of fuch Observations together, we might certainly know the true distance, or Parallax, of the Planet. And having any one true Parallax of thefe Planets, we might very eafily have the other by their apparent Diameters, which the Telescope likewife affords us very accurately. And thence their motions might be much better known, and their Theories more exactly regulated. And for this purpose I know not any one place more convenient for fuch an Observation to be made in, then in the Island of St. Helena, upon the Coaft of Africk, which lyes about fixteen degrees to the Southwards of the Line, and is very near, according to the lateft Geographical Maps, in the fame Meridian with London; for though they may not perhaps lye exactly in the fame, yet their Observations, being ordered according to what I shall anon shew, it will not be difficult to find the true distance of the Planet. But were they both under the fame Meridian, it would be much better.

And becaufe Obfervations may be much eafier, and more accurately made with good Telescopes, then with any other Instruments, it will not, I suppose, seem impertinent to explain a little what wayes I judge most fit and convenient for that particular. Such therefore as shall be the Observators for this purpose, should be furnished with the best Telescopes that can be had, the longer the better and more exact will their Obfervations be, though they are fomewhat the more difficultly manag'd. These should be fitted with a Rete, or divided Scale, plac'd at such a diftance within the Eye-glass, that they may be diffinctly feen, which should be the measures of minutes and seconds; by this Instrument each Obfervator should, at certain prefixt times, observe the Moon, or other Planet, in, or very near, the Meridian ; and because it may be very difficult to find two convenient stations that will happen to be just under the fame Meridian, they shall, each of them, observe the way of the Planet, both for an hour before, and an hour after, it arrive at the Meridian ; and by a line, or stroke, amongst the small fixed Stars, they shall denote out the way that each of them observ'd the Center of the Planet to be mov'd in for those two hours : These Observations each of them shall repeat for many dayes together, that both it may happen, that both of them

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them may fometimes make their Obfervations together, and that from divers Experiments we may be the better affured of what certainty and exactness fuch kind of Obfervations are like to prove. And because many of the Stars which may happen to come within the compass of fuch an *Iconifm*, or Map, may be fuch as are only visible through a good *Telefcope*, whose Positions perhaps have not been noted, nor their longitudes, or latitudes, any where remarked; therefore each Observator should indeavour to infert star, whose longitude, and latitude, is known; or with his *Telescope* he shall find the Position of some notable *telescopical* Star, inferted in his Map, to some known fixt Star, whose place in the *Zodiack* is well defin'd.

Having by this means found the true diftance of the Moon, and having observed well the apparent Diameter of it at that time with a good Telescope, it is easie enough, by one single Observation of the apparent Diameter of the Moon with a good Glass, to determine her distances in any other part of her Orbit, or Dragon, and confequently, fome few Observations will tell us, whether she be mov'd in an Ellipsis, (which, by the way, may also be found, even now, though I think we are yet ignorant of her true diftance) and next (which without fuch Observations, I think, we shall not be fure of) we may know exactly the bigness of that Ellipsis, or Circle, and her true velocity in each part, and thereby be much the better inabled to find out the true caufe of all her Motions. And though, even now alfo, we may, by fuch Observations in one station, as here at London, observe the apparent Diameter and motion of the Moon in her Dragon, and confequently be inabled to make a better ghess at the species or kind of Curve, in which she is mov'd, that is, whether it be fphærical, or elliptical, or neither, and with what proportional velocities she is carried in that Curve; yet till her true Parallax be known, we cannot determine either.

Next, for the true diftance of the Sun, the beft way will be, by accurate Observations, made in both these forementioned stations, of some convenient Eclipfe of the Sun, many of which may fo happen, as to be feen by both; for the Penumbra of the Moon may, if the be fixty Semidiameters diftant from the Earth, and the Sun above feven thousand, extend to about feventy degrees on the Earth, and confequently be feen by Observators as far distant as London, and St. Helena, which are not full fixty nine degrees diftant. And this would much more accurately, then any way that has been yet used, determine the Parallax, and distance, of the Sun; for as for the Horizontal Parallax I have already fhewn it fufficiently uncertain ; nor is the way of finding it by the Eclipfe of the Moon any other then hypothetical; and that by the difference of the true and apparent quadrature of the Moon is lefs not uncertain, witmess their Deductions from it, who have made use of it; for Vendeline puts that difference to be but 4'. 30". whence he deduces a vaft diftance of the Sun, as I have before fhewn. Ricciolo makes it full 30'. 00. but Reinoldus, and Kircher, no lefs then three degrees. And no wonder, for if we examine the Theory, we shall find it fo complicated with uncertainties. Firft,

lax tic tha Bel the aid in rat wa and tha wif ons wha refr hav oth it. F dow Нура Ecli hith Se Eart dow toge whic dark this I there Scher mosph term KH, twee BAL obfeu LB, fracte Ward agrea to N. luperi furthe

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First, From the irregular furface of the Moon, and from feveral Parallaxes, that unlefs the Dichotomy happen in the Nonagefimus of the Ecliptick, and that in the Meridian, $O \cdot c$. all which happen fo very feldom, that it is almost impossible to make them otherwise then uncertainly. Befides, we are not yet certain, but that there may be fomewhat about the Moon analogus to the Air about the Earth, which may caufe a refraction of the light of the Sun, and confequently make a great difference in the apparent dichotomy of the Moon. Their way indeed is very rational and ingenious; and fuch as is much to be preferr'd before the way by the Horizontal Parallax, could all the uncertainties be remov'd, and were the true diftance of the Moon known.

But becaufe we find by the Experiments of Vendiline, Reinoldus, &c. that Obfervations of this kind are very uncertain alfo: It were to be wifht, that fuch kind of Obfervations, made at two very diftant flations, were promoted. And it is fo much the more defirable, becaufe, from what I have now fhewn of the nature of the Air, it is evident, that the refraction may be very much greater then all the Aftronomers hitherto have imagined it: And confequently, that the diftance of the Moon, and other Planets, may be much leffe then what they have hitherto made it.

For first, this Inflection, I have here propounded, will allow the shadow of the Earth to be much shorter then it can be made by the other *Hypothesis* of refraction, and confequently, the Moon will not suffer an Eclipse, unless it comes very much nearer the Earth then the Astronomers hitherto have supposed it.

Secondly, There will not in this Hypothesis be any other shadow of the Earth, fuch as Kepler fuppofes, and calls the Penumbra, which is the fhadow of the refracting Atmosphere; for the bending of the Rays being altogether caus'd by Inflection, as I have already thewn, all that part which is afcribed by Kepler, and others after him, to the Penumbra, or dark part, which is without the umbra terra, does clear vanish; for in this Hypothesis there is no refracting surface of the Air, and consequently there can be no shadows, such as appear in the ninth Figure of the 37. scheme, where let ABCD represent the Earth, and EFGH the Atmosphere, which according to Keplers supposition, is like a Sphære of Water terminated with an exact furface EFGH, let the lines MF, LB, ID, KH, represent the Rays of the Sun; 'tis manifest, that all the Rayes between LB, and ID, will be reflected by the furface of the Earth BAD, and confequently, the conical space BOD would be dark and obscure; but, say the followers of Kepler, the Raysbetween MF, and LB, and between ID, and KH, falling on the Atmosphere, are refracted, both at their ingress and egress out of the Atmosphere, nearer towards the Axis of the spærical shadow CO, and consequently, inlighten a great part of that former dark Cone, and fhorten, and contract, its top to N. And because of this Reflection of these Rays, say they, there is superinduc'd another shell of a dark Cone FPH, whose ApexP is yet further distant from the Earth : By this Penumbra, fay they, the Moon 19

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is Eclipfed, for it alwayes passes between the lines 1 2, and 3 4.

To which Ifay, That if the Air be fuch, as I have newly fhewn it to be, and confequently caufe fuch an inflection of the Rays that fall into it, those dark *Penumbra's* FYZQ, HXVT, and ORPS, will all vanish. For if we suppose the Air indefinitely extended, and to be no where bounded with a determinate refracting furface, as I have shewn it uncapable of having, from the nature of it; it will follow, that the Moon will no where be totally obscured, but when it is below the Apex N, of the dark blunt Cone of the Earth's shadow: Now, from the suppose tion, that the Sun is distant about seven thousand Diameters, the point N, according to calculation, being not above twenty five terrestrial Semidiameters from the Center of the Earth: It follows, that whensoever the Moon eclipfed is totally darkned, without affording any kind of light, it must be within twenty five Semidiameters of the Earth, and confequently much lower then any Astronomers have hitherto put it.

This will feem much more confonant to the reft of the fecundary Planets; for the higheft of *Jupiter's* Moons is between twenty and thirty *Jovial Semidiameters* diftant from the Center of *Jupiter*; and the Moons of *saturn* much about the fame number of *Saturnial Semidiameters* from the Center of that Planet.

But these are but conjectures also, and must be determin'd by such kind of Observations as I have newly mention'd.

Nor will it be difficult, by this Hypothesis, to falve all the appearances of Eclipses of the Moon, for in this Hypothesis also, there will be, on each fide of the shadow of the Earth, a Penumbra, not caus'd by the Refraction of the Air, as in the Hypothesis of Kepler; but by the faint inlightning of it by the Sun : For if, in the fixth Figure, we suppose ESQ, and GSR, to be the Rays that terminate the shadow from either fide of the Earth; ESQ coming from the upper limb of the Sun, and GSR from the under; it will follow, that the fhadow of the Earth, within those Rays, that is, the Cone GSE, will be totally dark. But the Sun being not a point, but a large area of light, there will be a fecondary dark Cone of shadow EPG, which will be caus'd by the earth's hindring part of the Rays of the Sun from falling on the parts GPR, and EPQ. of which halved fhadow, or Penumbra, that part will appear brighteft which lyes nearest the terminating Rayes G P, and E P, and those darker that lye nearest to GS, and ES: when therefore the Moon appears quite dark in the middle of the Eclipse, the must be below S, that is, between S and F; when the appears lighter near the middle of the Eclipse, she must pass some where between R Q and S; and when she is alike light through the whole Eclypse, she must pass between RQ, and P. loi vineuppinoo bas . O D wobshi int ant on to a great parts f. that form e dish Conceand freeten, and contract, its top

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Observ. LIX. Of multitudes of small Stars discoverable by the Telescope.

Jupiter, before it be out of the day, ou risi

Aving, in the last Observation, premis'd some particulars observable in the medium, through which we must look upon Calestial Objects, I shall here add one Observation of the Bodies themselves ; and for a specimen I have made choice of the Pleiades, or seven Stars, commonly so called (though in our time and Climate there appear no more then fix to the naked eye) and this I did the rather, because the defervedly famous Galileo, having publisht a Picture of this Afterisme, was able, it feems, with his Glass to discover no more then thirty fix, whereas with a pretty good twelve foot Telescope, by which I drew this 38 Iconism, I could very plainly difcover feventy eight, placed in the order they are ranged in the Figure, and of as many differing Magnitudes as the Afterisks, wherewith they are Marked, do specifie; there being no lefs then fourteen feveral Magnitudes of those Stars, which are compris'd within the draught, the biggeft whereof is not accounted greater then one of the third Magnitude; and indeed that account is much too big, if it be compared with other Stars of the third Magnitude, especially by the help of a Telescope; for then by it may be perceiv'd, that its splendor, to the naked eye, may be fomewhat augmented by the three little Starsimmedi. ately above it, which are near adjoyning to it. The Telescope alfo difco. vers a great variety, even in the bigness of those, commonly reckon'd, of the first, second, third, fourth, fifth, and fixth Magnitude ; fo that should they be diffinguish'd thereby, those six Magnitudes would, at least, afford no lefs then thrice that number of Magnitudes, plainly enough difringuishable by their Magnitude, and brightness; fo that a good twelve foot Glafs would afford us no lefs then twenty five feveral Magnitudes. Nor are thefe all, but a longer Glass does yet further, both more nicely diftinguish the Magnitudes of those already noted, and also discover feveral other of fmaller Magnitudes, not difcernable by the twelve foot Glafs: Thus have I been able, with a good thirty fix foot Glafs, to difcover many more Stars in the Pleiades then are here delineated, and those of three or four diffinct Magnitudes lefs then any of those spots of the fourteenth Magnitude. And by the twinkling of divers other places of this Afterisme, when the Sky was very clear, I am apt to think, that with longer Glasses, or fuch as would bear a bigger aperture, there might be discovered multitudes of other small Stars, yet inconspicuous. And indeed, for the discovery of small Stars, the bigger the aperture be, the better adapted is the Glass; for though perhaps it does make the feveral specks more radiant, and glaring, yet by that means, uniting more Rays very near to one point, it does make many of those radiant points conspi-Kk cuous,

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MICROGRAPHIA.

cuous, which, by putting on a lefs aperture, may be found to vanish; and therefore, both for the discovery of the fixt Star, and for finding the *satellites* of *Jupiter*, before it be out of the day, or twilight, I alwayes leave the Object-glass as clear without any aperture as I can, and have thereby been able to discover the *satellites* a long while before; I was able to discern them, when the satellites a long while before; I was there times, to see multitudes of other stars, which a start aperture makes to discover.

In that notable Afterism also of the Sword of Orion, where the ingenious Monsieur Hugens van Zulichem has discovered only three little Stars in a cluster, I have with a thirty fix foot Glass, without any aperture (the breadth of the Glass being about some three inches and a half) discover'd five, and the twinkling of divers others up and down in divers parts of that small milky Cloud.

So that 'tis not unlikely, but that the meliorating of *Telefcopes* will afford as great a variety of new Difcoveries in the Heavens, as better *Microfcopes* would among fmall terreftrial Bodies, and both would give us infinite caufe, more and more to admire the omnipotence of the Creator.

Observ. LX. Of the Moon.

Aving a pretty large corner of the Plate for the feven Starrs, void, I for the filling it up, I have added one small specimen of the appearance of the parts of the Moon, by defcribing a fmall fpot of it, which, though taken notice of, both by the Excellent Hevelius, and called Mons Olympus (though I think fomewhat improperly, being rather a vale) and reprefented by the Figure X, of the 38. Scheme, and also by the Learn'd Ricciolus, who calls it Hipparchus, and describes it by the Figure Y, yet how far fhort both of them come of the truth, may be fomewhat perceiv'd by the draught, which I have here added of it, in the Figure Z, (which I drew by a thirty foot Glass, in October 1664. just before the Moon washalf inlightned) but much better by the Reader's diligently observing it himself, at a convenient time, with a Glass of that length, and much better yet with one of threefcore foot long; for through thefe it appears a very spacious Vale, incompassed with a ridge of Hills, not very high in comparison of many other in the Moon, nor yet very steep. The Vale it felf A BCD, is much of the figure of a Pear, and from feveral appearances of it, seems to be some very fruitful place, that is, to have its furface all covered over with fome kinds of vegetable fubftances; for in all politions of the light on it, it feems to give a much fainter reflection then the more barren tops of the incompassing Hills, and those a much fainter then divers other cragged, chalky, or rocky Mountains of the Moon. So that I am not unapt to think, that the Vale may have Vegetables

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Vegetables *analogus* to our Grafs, Shrubs, and Trees; and moft of thefe incompaffing Hills may be covered with fo thin a vegetable Coat, as we may observe the Hills with us to be, fuch as the fhort Sheep pasture which covers the Hills of *Salisbury* Plains.

Up and down in feveral parts of this place here defcrib'd (as there are multitudes in other places all over the furface of the Moon) may be perceived feveral kinds of pits, which are fhap'd almost like a difh, fome bigger, fome lefs, fome shallower, fome deeper, that is, they fem to be a hollow Hemisphere, incompassed with a round rising bank, as if the fubstance in the middle had been digg'd up, and thrown on either fide. These feem to me to have been the effects of some motions within the body of the Moon, analogus to our Earthquakes, by the eruption of which, as it has thrown up a brim, or ridge, round about, higher then the Ambient furface of the Moon, fo has it left a hole, or depreffion, in the middle, proportionably lower; divers places refembling fome of these, I have observ'd here in England, on the tops of some Hills, which might have been caus'd by fome Earthquake in the younger dayes of the world. But that which does most incline me to this belief, is, first, the generality and diverfity of the Magnitude of these pits all over the body of the Moon. Next, the two experimental wayes, by which I have made a representation of them.

The first was with a very fost and well temper'd mixture of Tobaccopipe clay and Water, into which, if I let fall any heavy body, as a Bullet, it would throw up the mixture round the place, which for a while would make a reprefentation, not unlike these of the Moon; but confidering the ftate and condition of the Moon, there feems not any probability to imagine, that it fhould proceed from any caufe analogus to this 3 for it would be difficult to imagine whence those bodies should come ; and next, how the fubftance of the Moon should be so foft; but if a Bubble be blown under the furface of it, and fuffer'd to rife, and break; or if a Bullet, or other body, funk in it, be pull'd out from it, thefe departing bodies leave an impression on the surface of the mixture, exactly like these of the Moon, fave that these also quickly subside and vanish. But the fecond, and most notable, representation was, what I observ'd in a pot of boyling Alabaster, for there that powder being by the eruption of vapours reduc'd to a kind of fluid confiftence, if, whil'ft it boyls, it be gently remov'd befides the fire, the Alabafter prefently ceafing to boyl, the whole furface, efpecially that where fome of the laft Bubbles have rifen, will appear all over covered with fmall pits, exactly shap'd like thefe of the Moon, and by holding a lighted Candle in a large dark Room, in divers politions to this furface, you may exactly reprefent all the Phanomena of these pits in the Moon, according as they are more or lefs inlightned by the Sun. And that there may have been in the Moon some such motion as this, which may have made these pits, will seem the more probable, if we suppose it like our Earth, for the Earthquakes here with us seem to proceed from some such cause, as the boyling of the pot of Ala-Kk 2 bafter,

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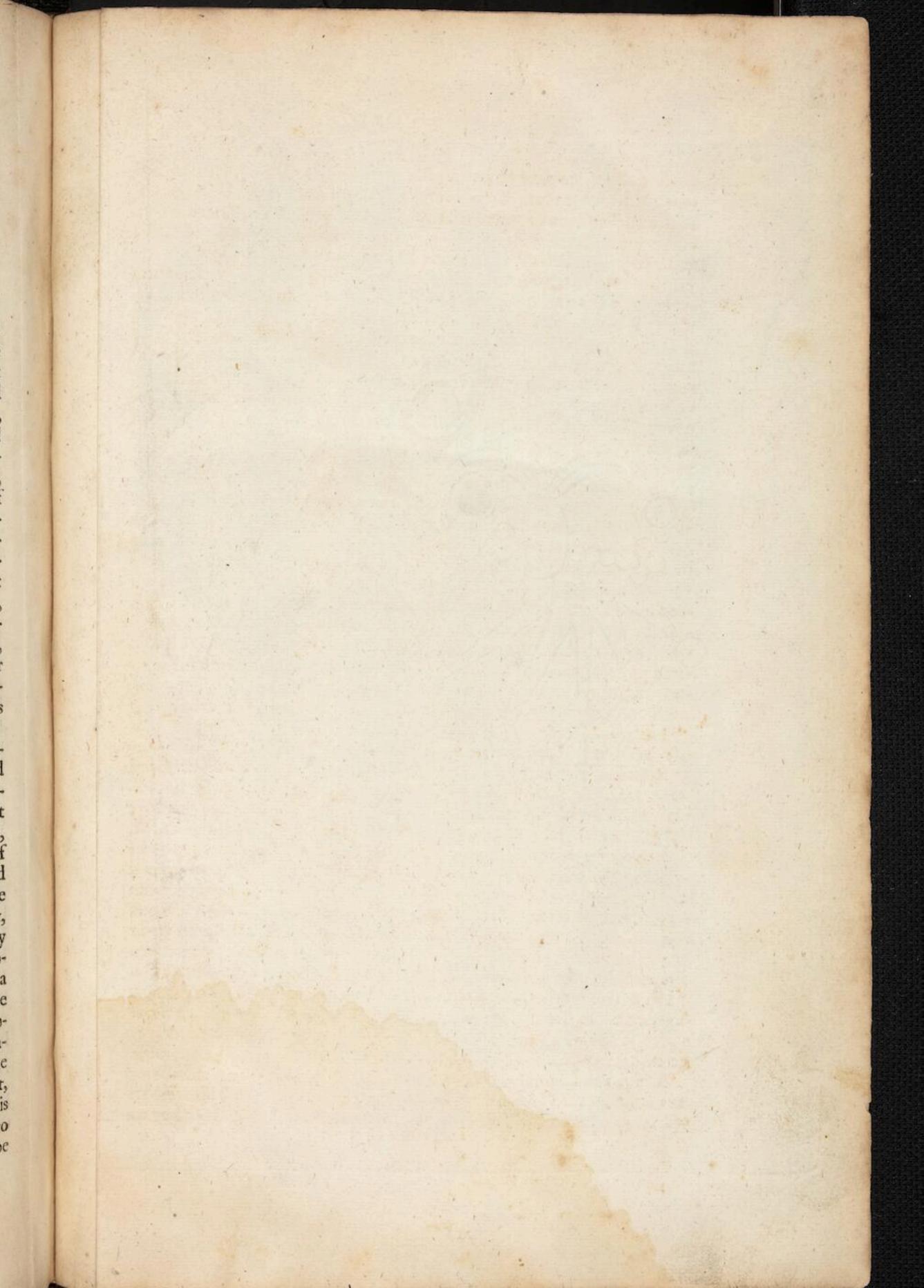
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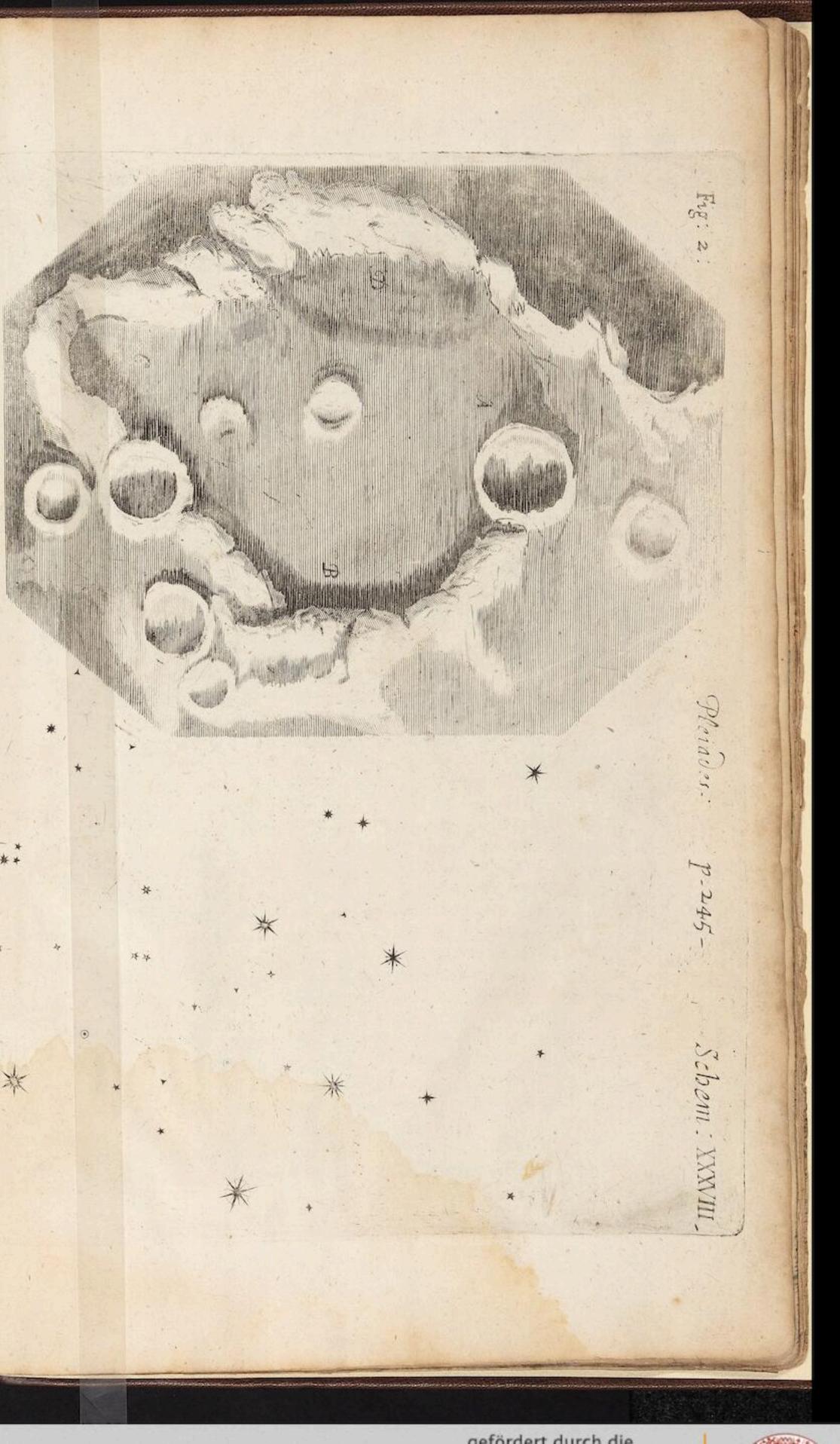
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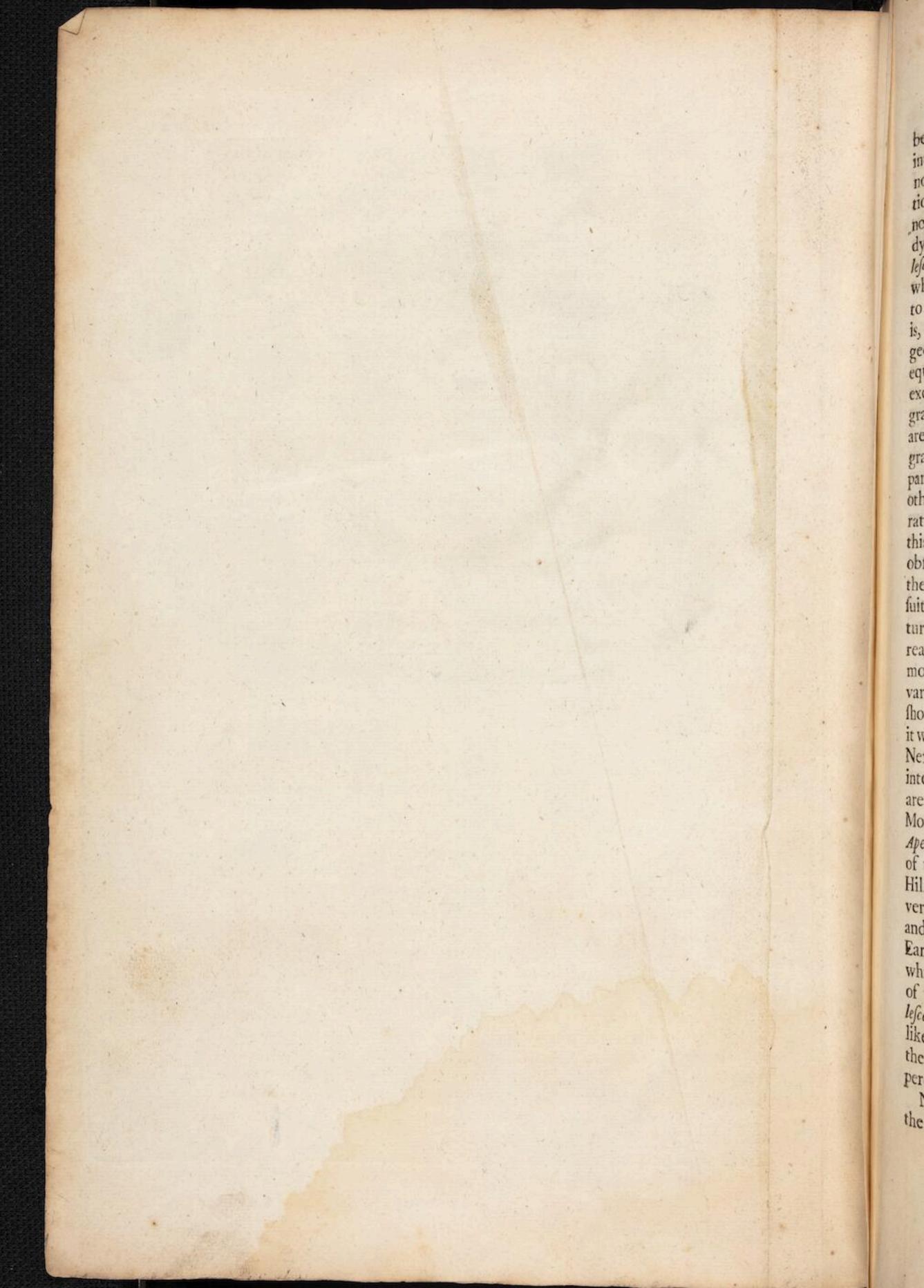
bafter, there feeming to be generated in the Earth from fome fubterraneous fires, or heat, great quantities of vapours, that is, of expanded aerial substances, which not prefently finding a passage through the ambient parts of the Earth, do, as they are increased by the supplying and generating principles, and thereby (having not fufficient room to expand themselves) extreamly condens'd, at last overpower, with their elastick properties, the refistence of the incompassing Earth, and lifting it up, or cleaving it, and fo fhattering of the parts of the Earth above it, do at length, where they find the parts of the Earth above them more loofe, make their way upwards, and carrying a great part of the Earth before them, not only raife a small brim round about the place, out of which they break, but for the most part confiderable high Hills and Mountains, and when they break from under the Sea, divers times, mountainous Islands; this feems confirm'd by the Fulcans in feveral places of the Earth, the mouths of which, for the most part, are incompaffed with a Hill of a confiderable height, and the tops of those Hills, or Mountains, are usually shap'd very much like these pits, or dishes, of the Moon : Instances of this we have in the descriptions of Ætna in Sicily, of Hecla in Iceland, of Tenerif in the Canaries, of the feveral Vulcans in New-Spain, defcrib'd by Gage, and more efpecially in the eruption of late years in one of the Canary Islands. In all of which there is not only a confiderable high Hill raifed about the mouth of the Vulcan, but, like the spots of the Moon, the top of those Hills are like a dish, or baion. And indeed, if one attentively confider the nature of the thing, one may find fufficient reason to judge, that it cannot be otherwise; for these eruptions, whether of fire, or fmoak, alwayes rayling great quantities of Earth before them, must necessarily, by the fall of those parts on either fide, raife very confiderable heaps.

Now, both from the figures of them, and from feveral other circumitances; these pits in the Moon seem to have been generated much after the fame manner that the holes in Alabaster, and the Vulcans of the Earth are made. For first, it is not improbable, but that the lubstance of the Moon may be very much like that of our Earth, that is, may confift of an earthy, fandy, or rocky fubstance, in feveral of its superficial parts, which parts being agitated, undermin'd, or heav'd up, by eruptions of vapours, may naturally be thrown into the fame kind of figured holes, as the fmall duft, or powder of Alabaster. Next, it is not improbable, but that there may be generated, within the body of the Moon, divers fuch kind of internal fires and heats, as may produce fuch Exhalations; for fince we can plainly enough discover with a Telescope, that there are multitudes of fuch kind of eruptions in the body of the Sun it felf, which is accounted the most noble Ætherial body, certainly we need not be much scandaliz'd at such kind of alterations, or corruptions, in the body of this lower and lefs confiderable part of the universe, the Moon, which is only secundary, or attendant, on the bigger, and more confiderable body of the Earth. Thirdly, 'tis not unlikely, but that supposing such a fandy or mouldring substance to be



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be there found, and supposing also a possibility of the generation of the internal elastical body (whether you will call it air or vapours) tis not unlikely. I fay, but that there is in the Moon a principle of gravitation, fuch as in the Earth. And to make this probable, I think, we need no better Argument, then the roundness, or globular Figure of the body of the Moon it felf, which we may perceive very plainly by the Telescope, to be (bating the small inequality of the Hills and Vales in it, which are all of them likewife fhap'd, or levelled, as it were, to answer to the center of the Moons body) perfectly of a Sphærical figure, that is, all the parts of it are for ang'd (bating the comparitively fmall ruggednefs, of the Hills and Dales) that the outmost bounds of them are equally diftant from the Center of the Moon, and confequently, it is exceedingly probable allo, that they are equidiftant from the Center of gravitation; and indeed, the figure of the superficial parts of the Moon are fo exactly fhap'd, according as they fhould be, fuppofing it had a gravitating principle as the Earth has, that even the figure of those parts themselves is of sufficient efficacy to make the gravitation, and the other two fuppolitions probable: fo that the other fuppolitions may be rather prov'd by this confiderable Circumstance, or Observation, then this suppos'd Explication can by them; for he that shall attentively observe with an excellent Telescope, how all the Circumstances, notable in the shape of the superficial parts, are, as it were, exactly adapted to fuit with fuch a principle, will, if he well confiders the ufual method of Nature in its other proceedings, find abundant argument to believe it to have really there also such a principle; for I could never observe, among all the mountainous or prominent parts of the Moon (whereof there is a huge variety) that any one part of it was plac'd in fuch a manner, that if there fhould be a gravitating, or attracting principle in the body of the Moon, it would make that part to fall, or be mov'd out of its visible posture. Next, the shape and position of the parts is such, that they all feem put into those very shapes they are in by a gravitating power : For first, there are but very few clifts, or very fteep declivities in the afcent of these Mountains; for befides those Mountains, which are by Hevelius call'd the Apennine Mountains, and fome other, which feem to border on the Seas of the Moon, and those only upon one fide, as is common also in those Hills that are here on the Earth; there are very few that feem to have very freep afcents, but, for the most part, they are made very round, and much refemble the make of the Hills and Mountains also of the Earth ; this may be partly perceived by the Hills incompating this Vale, which I have here defcrib'd ; and as on the Earth alfo, the middlemost of these Hills seems the highest, so is it obvious also, through a good Telescope, in those of the Moon ; the Vales also in many are much shap'd like those of the Earth, and I am apt to think, that could we look upon the Earth from the Moon, with a good Telescope, we might eafily enough perceive its furface to be very much like that of the Moon. Now whereas in this fmall draught, (as there would be multitudes if the whole Moon were drawn after this manner) there are feveral little Ebullitions,

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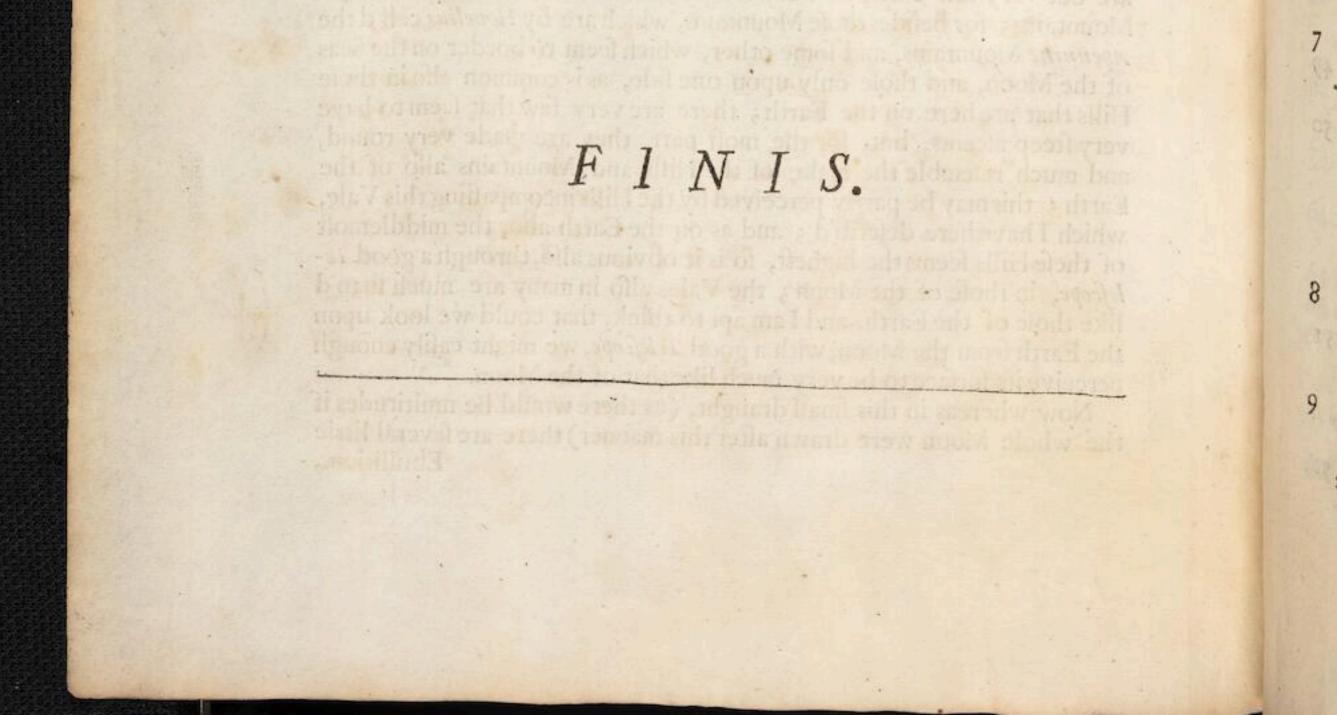
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Ebullitions, or Difhes, even in the Vales themfelves, and in the incompaffing Hills alfo; this will, from this fuppolition, (which I have, I think, upon very good reafon taken) be exceeding eafily explicable; for, as I have feveral times alfo obferv'd, in the furface of Alabaster fo ordered, as I before defcrib'd, fo may the later eruptions of vapours be even in the middle, or on the edges of the former; and other fucceeding these alfo in time may be in the middle or edges of these, $\mathcal{O}c$. of which there are Inftances enough in divers parts of the body of the Moon, and by a boyling pot of Alabaster will be fufficiently exemplifi'd.

To conclude therefore, it being very probable, that the Moon has a principle of gravitation, it affords an excellent diffinguishing Instance in the fearch after the caufe of gravitation, or attraction, to hint, that it does not depend upon the diurnal or turbinated motion of the Earth, as fome have fomewhat inconfiderately supposed and affirmed it to do; for if the Moon has an attractive principle, whereby it is not only shap'd round, but does firmly contain and hold all its parts united, though many of them feem as loofe as the fand on the Earth, and that the Moon is not mov'd about its Center; then certainly the turbination cannot be the caufe of the attraction of the Earth; and therefore fome other principle must be thought of, that will agree with all the fecundary as well as primary Planets. But this, I confess, is but a probability, and not a demonstration, which (from any Observation yet made) it seems hardly capable of, though how fuccessful future indeavours (promoted by the meliorating of Glaffes, and observing particular circumstances) may be in this, or any other, kind, must be with patience expected.

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Oculus Mundi: some other Conside-99 rations and Experiments about the porousness of Bodies: some other Con-100 siderations about the propagation of light and refraction.

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145 Veins. A very remarkable History out of Bellonius; and some Considerations about staining and dying of Bodies.

Observ. 26. Of Cowage.

The description of it out of Parkin-146 fon: an Experiment made of it : a description, and some conjectures at the cause of the Phænomena.

> Observ. 27. Of the Beard of a wild Oat.

147 148 The description of its Shape and 149 properties: the manner of making a 150 Hygroscope with it; and a Conje-151 Eture at the causes of these motions, 152 and of the motions of the Muscles.

Observ. 28. Of the Seeds of Ve.

Observ. 31. Of Purslane Seeds. 156

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A description of these and many other Seeds.

Observ. 32. Of Hair.

The description of several sorts of 158 Hair; their Figures and Textures: the reason of their colours, A descripti-159 on of the texture of the skin, and of 160 Spunk and Sponges: by what pass-161 sages and pores of the skin transpiration seems to be made. Experiments to prove the porousness of the skin of Vegetables.

Observ. 33. Of the Scales of a 162 Soale.

A description of their beauteous form.

Observ. 34. Of the Sting of a Bee. 163

A description of its Shape, mechas 164 nisme, and use.

Observ. 35. Of Feathers. 165 166 A description of the shape and cu- 167 rious contexture of Feathers : and some conjectures thereupon.

nice Looking-glass.

153 The description of them.

Obser. 29. Of the Seeds of Time.

154 A description of them. A digression about Natures method.

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A description of their curious form 168 and proprieties; with a conjecture at 169 the cause of their variable colours.

Obser. 37. Of the Feet of Flyes, and other Insects.

A defeription of their figure, parts, 170 and use; and some confiderations 171 thereupon.

Observ.

172 Obfer. 38. Of the Wings of Flyes.

After what manner, and how (wift-173 ly the wings of Infects move. A de-(cription of the Pendulums under the 174 wings, and their motion: the shape and structure of the parts of the wing.

175 Obfer. 39. Of the Head of a Fly.

1. All the fase of a Drone-fly is nothing almost but eyes. 2. Those are 176 of two magnitudes. 3. They are Hemispheres, and very reflective and (mooth. 4. Some directed towards every quarter. 5. How the Fly cleanses them.6 Their number. 7. Their order : 177 divers particulars observ'd in the dis 178 (efting a head. That these are very probably the eyes of the Creature ; ar. gued from several Observations and 179 Experiments, that Crabs, Lobsters, Shrimps, seem to be water Infects, and to be framed much like Air Infects. 180 Several Confiderations about their manner of vision.

Obser.40. Of the Teeth of a Snail.

A brief description of it. 181

> Observ. 41. Of the Eggs of Silk. worms.

greffive; and transformation. A Hilto- 187 ry fomewhat Analogus cited out of Pifo. Several Observations about the 183 various wayes of the generations of Infects : by what means they act fo 189 seemingly wifely and prudently Seve- 190 ral Quæries propounded. Post (cript, 191 containing a relation of another very 192 odd way of the generation of Infects. An Observation about the fertility of the Earth of our Climate in producing Infects, and of divers other wayes of 193 their generation.

Observ. 44. Of the tufted Gnat.

Several Observables about Insects, and a more particular description of 194 the parts of this Gnat.

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Ob.45. Of the great belly'd Gnat. 195

A Short description of it.

Obser. 46. Of a white Moth.

- A description of the feathers and 196 wings of this, and several other In- 197 fects. Divers Considerations about the 198 wings, and the flying of Infects and Birds.

Obf. 47. Of the Shepherd Spider.

182 Several Observables about the Eggs of Infects:

Observ. 42. Of a blue Fly. 183

184 A description of its outward and inward parts. Its hardiness to indure 185 freezing, and steeping in Spirit of wine.

Observ. 43. Of a water Insect.

A description of its Shape, transpa-186 rency, motion, both internal and pro-

A description of its Eyes : and the fockets of its long legs: and a Conje- 199 Eture of the mechanical reason of its fabrick; together with a supposition, that'tis not unlikely, but Spiders may have the make of their inward parts exactly like a Crab, which may be 200 call'd a water Spider.

Obfer.48. Of the hunting Spider.

A short description of it ; to which is annext an excellent History of it, 201 made by Mr. Evelyn. Some further Obfer-Mm

202 Observations on other Spiders, and their Webs, together with an examination of a white Substance flying up and down in the Air after a Fog.

Obser. 49. Of an Ant.

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That all small Bodies, both Vegetable and Animal, do quickly dry and wither. The best remedy I found to hinder it, and to make the Animal lye still 204 to be observed. Several particulars related of the actions of this Creature; 205 and a short description of its parts.

Obf. 50. Of the wandring Mite.

206 A description of this Creature, and of another very small one, which usual of any bore it company. A Conjecture at the original of Mites.

Observ. 51. Of a Crab.like Insect.

208 A brief description of it.

Observ. 52. Of a Book-worm.

209 A description of it; where by the way is inserted a digreffion, experimentally explicating the Phænome210 na of Pearl. A confideration of its digestive faculty.

Observ. 53. Of a Flea.

mation of the variety of forms in other Mites, with a Conjecture at the rea- 215 fon.

Ob. 56. Of small Vine-Mites.

A description of them; a gheß at their original; their exceeding smalness compar'd with that of a Wood-216 louse, from which they may be supposed to come.

Observ. 57. Of Vinegar-worms.

A description of them, with some 217 confiderations on their motions.

Obf. 58. Of the Inflection of the Rays of Light in the Air.

A Shortrebearfal of several Phz- 218 nomena. An attempt to explicate 219 them: the supposition founded on two Propositions, both which are indeavoured to be made out by several Experiments. What density and rarity is in refpect of refraction: the refraction of Spirit of Wine compared with that of common Water : the refraction 220 of Ice. An Experiment of making an Undulation of the Rays by the mixing of Liquors of differing density. The explication of inflection, mechani. cally and hypothetically : what Bodies have (uch an inflection. Several Experiments to shew that the Air has this propriety; that it proceeds from 222 the differing density of the Air : that the upper and under part of the Air are of differing density : some Experi- 223 ments to prove this. A Table of the strength of the (pring of the Air, an. [wering to each degree of extension; when first made, and when repeated. 224 Another Experiment of compressing 225 the Air. A Table of the strength of the 225 Air, answering to each compression and expansion 3 from which the height

211 A short description of it. Observ. 54. Of a Louse.

212 A description of its parts, and some 213 notable circumstances.

Observ. 55. Of Mites.

The exceeding smalness of some Mites, and their Eggs. A description 214 of the Mites of Cheese: and an inti-

227 of the Air may be suppos'd indefinite;
228 to what degree the Air is rarifi'd at any distance above the Surface of the Earth : how, from this, Inflection is
229 inferr'd; and several Phænomena
230 explain'd. That the Air near the Earth is compos'd of parts of differing
231 density; made probable by several Experiments and Observations; how this propriety produces the effects of the waving and dancing of Bodies; and of the twinkling of the Stars.
233 Several Phænomena explicated. Some Quæries added.

 Woether this Principle may not be made use of, for perfecting Optick
 234 Glass? What might be hoped from it if it were to be done?

2. Whether from this Principle the apparition of some new Stars may not be explicated?

3. Whether the height of the Air may be defined by it?

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4. Whether there may not fometimes be so great a disparity of density between the upper and under parts of the Air, as to make a reflecting Surface?

235 S. Whether, if fo, this will not explicate the Phænomena of the Clouds. An Experiment to this purpose?

236 7. Whether the Rayes from the top of Mountains are not bended into Curve-lines by inflection? An Argument for it, taken from an Experiment made on St. Paul's Steeple. certain. That the distance of the Moon may be less then it has been hitherto supposed. Kepler's Supposition not so probable: the explication of 240 the Phænomena by another Hypothesis.

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A description of a Vale in the Moon; what call d by Hevelius and Ricciolus, and how describ'd by them: with what substances the hills of the 243 Moon may be cover'd. A description of the pits of the Moon, and a conje-Eture at their caule : two Experiments that make it probable, that of the fur= face of boyl'd Alabaster dust seeming 244. the most likely to be resembled by eruptions of vapours out of the body of the Moon: that Earthquakes seem to be generated much the fame way, and their effects (eem very similar. An Are gument that there may be fuch variations in the Moon, because greater have been observ'd in the Sun:because 245 the substance of the Moon and Earth feem much alike : and becaufe 'tis probable the Moon has a gravitating principle : this is argued from several particulars. The reason why several pits are one within another. The use 245 that may be made of this Instance of a gravity in the Moon, ERRATA.

 8. Whether the diftance of the Planets will not be more difficult to
 237 be found? What wayes are most likely to restifie the distance of the Moon: the way of fitting Telescopes for fuch Observations. How to make the
 38 Observations, and how from them to find the true distance of the Moon at any time. How the distance of the Sun may be found by two Observators. The
 739 way by the Dicatomy of the Moon un.

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Page 13. line ult. read safte : p. 34. 1.18.r. fmall lens : 1. penult. r. that proceeds from : p. 40. 1. 44.r. when you: p. 48. 1. 34. r. broadeft: p. 57. 1. 39. dele be: p. 62. 1. 36. r. water-drop : p. 64. 1. 9. r. duttion of G A C H : 1. 35. r. imprefsions : p. 96. 1. 33. r. compose : p. 100. 1. 11. r. Merfennus : p. 106 1. 8. r. extreamly : p. 110 1. 8. r. as : 1. 12. r. those : p. 112. 1. 32. r. Aldronandus, Wormius : p. 121. 1. 9. dele of : p. 128. 1. 43, dele from : p. 129. 1. 18. r. fish place : p. 130. 1. 29. r. Aerial menferuum : p. 136. 1. 39. r. knew how : p. 144. 1. 2. r. parts of the : p. 147, 1. 36. r. look'd on : p. 161. 1. 13. r. body : p. 162. 1. 17. dele only : p. 166. 1. 11. r. 22 : 1. 12. dele the Semicolon : 1. 17. r. place : p. 167. 1. 40. r. 22: p. 172. 1. 18. r. and first for the : p. 198. 1. 17. r. and an artific. p. 215. 1. ult. r. and from the : p. 211. 1. 4. r. whence the under : p. 234. 1. 18. r. to hope : p. 238. 1. 42. r. is not left : p. 240. 1. 19. r. Moon.

