THE

PHILOSOPHY

OF

NATURAL HISTORY.

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TO

HIS ROYAL HIGHNESS

GEORGE

PRINCE OF WALES,

THE PHILOSOPHY OF NATURAL HISTORY

IS MOST HUMBLY DEDICATED,

BY HIS DEVOTED SERVANT

WILLIAM SMELLIE.

PREFACE.

EVERY Preface, beſide occaſional or explanatory remarks, ſhould contain not only the general deſign of the work, but the motives and circumſtances which induced the author to write upon that particular ſubject. If this plan had been univerſally obſerved, prefaces would have exhibited a ſhort, but a curious and uſeful, hiſtory both of literature and of authors. Influenced by this idea, I ſhall give a very compendious account of the origin, deſign, and progreſs of the following work.

About fifteen years ago, in a converſation with the late worthy, reſpectable, and ingenious LORD KAMES, upon the too general neglect of natural knowledge, his Lordſhip ſuggeſted the idea of compoſing a book on the PHILOSOPHY OF NATURAL HISTORY. In a work of this kind, he propoſed that the productions of Nature, which to us are almoſt infinite, ſhould, in-

ſtead

ſtead of being treated of individually, be arranged under general heads; that, in each of theſe diviſions, the known facts, as well as reaſonings, ſhould be collected and methodiſed in the form of regular diſcourſes; that as few technical terms as poſſible ſhould be employed; and that all the uſeful and amuſing views ariſing from the different ſubjects ſhould be exhibited in ſuch a manner as to convey both pleaſure and information.

This taſk his Lordſhip was pleaſed to think me not altogether unqualified to attempt. The idea ſtruck me. I thought that a work of this kind, if executed even with moderate abilities, might excite a taſte for examining the various objects which every where ſolicit our attention. A habit of obſervation refines our feelings. It is a ſource of intereſting amuſement, prevents idle or vicious propenſities, and exalts the mind to a love of virtue and of rational entertainment. I likewiſe reflected, that men of learning often betray an ignorance on the moſt common ſubjects of Natural Hiſtory, which it is painful to remark.

I have been occaſionally employed, ſince the period which I have mentioned, in collecting and digeſting materials from the moſt authentic ſources. Theſe materials

materials I have interſperſed with ſuch obſervations, reflections, and reaſonings, as occurred to me from conſidering the multifarious ſubjects of which I have ventured to treat. I knew that a deliberate peruſal of the numerous writers from Ariſtotle downwards, would require a conſiderable portion of time. But the avocations of buſineſs, and the tranſlating of a work ſo voluminous as the *Natural Hiſtory of the* COUNT DE BUFFON, rendered my progreſs much ſlower than I wiſhed. I now, however, with much diffidence, ſubmit my labours to public opinion. An examination of the *Contents*, however, will convey a more clear idea of the nature of the work than a multiplicity of words. But I thought it proper to prefix a ſhort account of the circumſtances and motives which induced me to engage in an undertaking ſo extenſive, and ſo difficult to perform with tolerable ſucceſs.

With regard to the manner of writing, it is perhaps impoſſible for a North Briton, in a work of any extent, to avoid what are called *Scotticiſms*. But I have endeavoured to be every where perſpicuous, and to ſhun every ſentiment or expreſſion which might have a tendency to injure ſociety, or to hurt the feelings of individuals.

Indulgent

Indulgent readers, though they muſt perceive errors and imperfections, will naturally make ſome allowance for the variety of reſearch, and the labour of condenſing ſo much matter into ſo ſmall a compaſs. He is a bad author, it has been ſaid, who affords neither an aphoriſm nor a motto.

I cannot refrain from mentioning a circumſtance which has often made me uneaſy. The expectations of ſome friends were higher than I was conſcious my abilities could reach.

Upon the whole, the general deſign of this publication is, to convey to the minds of youth, and of ſuch as may have paid little attention to the ſtudy of Nature, a ſpecies of knowledge which it is not difficult to acquire. This knowledge will be a perpetual and inexhauſtible ſource of manly pleaſures; it will afford innocent and virtuous amuſement, and will occupy agreeably the leiſure or vacant hours of life.

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Page 286. *line* 6. *dele* their.

Page 383. *line* 6. from the bottom, *for* ſpeeders *read* ſpiders.

THE

PHILOSOPHY

OF

NATURAL HISTORY.

CHAPTER I.

Distinguishing characters of Animals, Plants, and Minerals—The Analogies between the plant and animal, arising from their structure and organs, their growth and nourishment, their dissemination and decay.

NATURAL Bodies, when viewed as they have a relation to man, are marked with characters so apparent, that they escape not the observation of the most unenlightened minds. In a system where all the constituent parts have a reciprocal dependence, and are connected by relations so subtile as to elude the perception of animals, such obvious characters were indispensible. Without them, neither the affairs of human life, nor the functions of the brute creation, could be carried on. Characters of this kind are accommodated to the apprehension of brutes and of vulgar men.

But, when the productions of nature are more closely examined; when they are scrutinized by the eye of philosophy, the number of their relations and differences is discovered to be almost infinite; and their shades of discrimination are often so delicate, that no sense can perceive them. Nothing, apparently, is more easy than to distinguish an animal from a plant; and yet the proper distinction has puzzled the most acute inquirers, and perhaps exceeds the limits of human capacity.

'A plant,' says Jungius, 'is a *living*, but not a *sentient* body, 'which is fixed in a determined place, and grows, increases 'in size, and propagates its species *.' In this definition living powers are ascribed to vegetables; but they are denied the faculty of sensation. Life, without some degree of sensation, is an incomprehensible idea. An animal limited to the sense of feeling alone, is the lowest conception we can form of life. Deprive this being of the only sense it possesses, and, though its figure should remain, we would instantly conclude it to be as inanimate as a stone. The life attributed to plants seems to be nothing more than an analogical deduction from their growth, nutrition, continuation of their species, and similar circumstances.

Ludwig defines vegetables to be 'Natural bodies, always endowed with the same form, but deprived of the power of local 'motion †.' Every branch of this definition is, with equal propriety, applicable to precious stones, salts, and some animals; and, therefore, requires no farther attention.

Sir

* Raii Hist. Plant. p. 1. † Ludwig, Phil. Bot. p. 1.

Sir Charles Linnaeus, in his Fundamenta Botanica, intends to difcriminate the three kingdoms of Nature in two lines. 'Stones,' fays he, '*grow*; vegetables grow and *live*; animals grow, live, 'and *feel* *.' This is an affemblage of words, the meaning of which is entirely perverted. The idea of growth implies nutrition and expanfion by the intervention of organs. The magnitude of ftones may be augmented by an accretion of new matter. But this is not growth, or expanfion of parts. The fecond definition, 'That vegetables grow and *live*,' is equally inaccurate. Inftead of proving the life of plants, Linnaeus takes it for granted, and makes it the characteriftic between vegetables and brute matter. The third, 'That animals grow, live, and *feel*,' is not lefs exceptionable. Growth, life, and mere fenfation, convey the moft ignoble notions of animated beings. From this definition, we would be led to imagine, that Linnaeus meant to defcribe the condition of a polypus or an oyfter. All animals, it is true, grow, live, and feel: But thefe are only the paffive properties of animals. The definition includes none of thofe inftinctive, intellectual, and active powers which exalt the animal above the vegetable, and fo eminently diftinguifh the different tribes from each other.

Thefe and many other abortive attempts have been made to afcertain the precife boundaries between the animal and vegetable. Definitions have been the perpetual aim of moft writers on this fubject. But definitions, when applied to natural objects, muft always be vague and elufory. We know not the principle of animal life. We are equally ignorant of the effential caufe of vegetable exiftence. It is vain, therefore, to dream of being able to define what we never can know. We may, however, difcover fome qualities common to the animal as well as to the vegetable.

* Fund. Bot. § 3.

Senſation, motion, and ſtructure of parts, give animals a more extenſive range in their connection with external objects. A certain portion of intellect, joined to the vital principle, ſeem to be the moſt diſtinguiſhing properties of animals, and to conſtitute their eſſence or being. Animals will, determine, act, and have a communication with diſtant objects by their ſenſes. They have the laws of nature, in ſome meaſure, at command. They protect themſelves from injury by employing force, ſwiftneſs, addreſs, and cunning. But vegetables remain fixed in the ſame place, and are ſubject to every thing that moves. Animals eat at intervals; their food requires time for digeſtion, and to anſwer the complicated purpoſes of ſecretion and nutrition. The ſtructure of plants is more ſimple: They receive perpetual nouriſhment without injury. Animals ſearch for and ſelect particular kinds of food. But plants muſt receive whatever is brought to them by the different elements. Animals exiſt on the ſurface and in the interior parts of the earth, in the air, in water, in the bodies of men and other animals, in the internal parts of plants, and even in ſtones. But, if we except a few aquatics, plants are fixed to the earth by roots.

All animals, it has been affirmed, have a heart, or particular fountain for propelling and diſtributing their fluids to the different parts of their bodies: But caterpillars, and many other inſects, have no ſuch general receptacle.

The loco-motive faculty has been conſidered as peculiar to animals. But even this character is extremely ſuſpicious. Oyſters, ſea-nettles, the gall-inſects, and a variety of other animals, can hardly be ſaid to enjoy the power of local motion. Many ſpecies remain for ever fixed to the rocks on which they are produced, and have no motion but that of extending or contracting their bodies. Beſides, examples of different kinds of motion are diſ-

coverable

coverable in the vegetable kingdom. When the roots of a tree meet with a ſtone, or any other obſtruction to their motion, in order to avoid it, they change their former direction. They turn from barren to fertile earth, which indicates ſomething analogous to a ſelection of food. Like the polypus, plants, when confined in a houſe, uniformly bend toward the window or aperture through which the rays of light are introduced.

The ſenſitive plant poſſeſſes the faculty of motion in an eminent degree. The ſlighteſt touch makes its leaves ſuddenly ſhrink, and, together with the branch, bend down toward the earth. But the moving plant, or hedyſarum movens, of which there are ſpecimens in the botanic garden of Edinburgh, furniſhes the moſt aſtoniſhing example of vegetable motion. It is a native of the Eaſt Indies. Its movements are not excited by the contact of external bodies, but ſolely by the influence of the ſun's rays. The motions of this plant are confined to the leaves, which are ſupported by long flexible footſtalks. When the ſun ſhines, the leaves move briſkly in every direction. Their general motion, however, is upward and downward: But they not unfrequently turn almoſt round; and then their footſtalks are evidently twiſted. Theſe motions go on inceſſantly as long as the heat of the ſun continues: But they ceaſe during the night, and when the weather is cold and cloudy. Our wonder is excited by the rapidity and conſtancy of the movements peculiar to this plant. The frequency, however, of ſimilar motions in other plants, renders it probable that the leaves of all vegetables move, or are agitated by the rays of the ſun, though many of theſe movements are too ſlow for our perception.

The American plant called *dionaea muſcipula*, or *Venus's fly-trap*, affords another inſtance of rapid vegetable motion. Its leaves are jointed, and furniſhed with two rows of ſtrong prickles. Their ſurfaces

ſurfaces are covered with a number of minute glands, which ſecrete a ſweet liquor, and allure the approach of flies. When theſe parts are touched by the legs of a fly, the two lobes of the leaf inſtantly riſe up, the rows of prickles lock themſelves faſt together, and ſqueeze the unwary animal to death. If a ſtraw or a pin be introduced between the lobes, the ſame motions are excited.

When a ſeed is ſown in a reverſed poſition, the young root turns downward to enter the earth, and the ſtem bends upward into the air. Confine a young ſtem to an inclined poſition, and its extremity will ſoon aſſume its former perpendicular direction. Twiſt the branches of any tree in ſuch a manner that the inferior ſurfaces of the leaves are turned toward the ſky, and you will, in a ſhort time, perceive that all theſe leaves reſume their original poſition. Theſe motions are performed ſooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as thoſe of the mallow, follow the courſe of the ſun. In the morning, their ſuperior ſurfaces are preſented to the eaſt; at noon, they regard the ſouth; and, when the ſun ſets, they are directed to the weſt. During the night, or in rainy weather, theſe leaves are horizontal; and their inferior ſurfaces are turned toward the earth.

What has been denominated the Sleep of Plants, affords an inſtance of another ſpecies of vegetable motion. The leaves of many plants fold up during the night; but, at the approach of the ſun, they expand with renewed vigour. The common appearances of moſt vegetables are ſo changed in the night, that it is difficult to recogniſe the different kinds, even by the aſſiſtance of light.

The modes of folding in the leaves, or of ſleeping, are extremely various. But it is worthy of remark, that they all diſpoſe themſelves

ſelves ſo as to give the beſt protection to the young ſtems, flowers, buds, or fruit. The leaves of the tamarind-tree contract round the tender fruit, and protect it from the nocturnal cold. The caſſia or ſenna, the glycine, and many of the papilionaceous plants, contract their leaves in a ſimilar manner. The leaves of the chickweed, of the aſclepias, atriplex, &c. are diſpoſed in oppoſite pairs. During the night, they riſe perpendicularly, and join ſo cloſe at the top, that they conceal the flowers. The leaves of the ſida or althaea Theophraſti, of the ayenia, and oenothera, are placed alternately. Though horizonal, or even depending, during the day, at the approach of night they riſe, embrace the ſtem, and protect the tender flowers. The leaves of the ſolanum, or nightſhade, are horizontal during the day; but, in the night, they riſe and cover the flowers. The Egyptian vetch erects its leaves during the night, in ſuch a manner that each pair ſeem to be one leaf only. The leaves of the white lupine, in the ſtate of ſleep, hang down, and protect the young buds from being injured by the nocturnal air.

Theſe and ſimilar motions are not peculiar to the leaves of plants. The flowers have alſo the power of moving. During the night, many of them are incloſed in their calixes. Some flowers, as thoſe of the German ſpurge, geranium ſtriatum, and common whitlow graſs, when aſleep, hang their mouths toward the earth, to prevent the noxious effects of rain or dew.

The cauſe of thoſe movements which conſtitute the ſleep of plants, has been aſcribed to the preſence or abſence of the ſun's rays. In ſome of the examples I have given, the motions produced are evidently excited by heat. But plants kept in a hot-houſe, where an equal degree of heat is preſerved both day and night, fail not to contract their leaves, or to ſleep, in the ſame manner as when they are expoſed to the open air. This fact evinces, that the ſleep of plants

plants is rather owing to a peculiar law, than to a quicker or flower motion of their juices.

A ftomach and brain have been reckoned effential characteriftics of the animal; and plants are faid to poffefs nothing analogous to thefe organs. But the polypus has no ftomach; or rather, like vegetables, its whole body may be confidered as a ftomach. Its internal cavity contains no vifcera; and, when this animal is turned outfide in, it ftill continues to live, and to digeft its food, in the fame manner as if it had received no injury. The mode by which plants are nourifhed is extremely analogous. They imbibe food by the roots, the trunk, the branches, the leaves, and the flowers. Inftead, therefore, of having no ftomach, their whole ftructure is ftomach. With regard to the brain, the polypus, and many other infects, are deprived of that organ. Hence neither ftomach nor brain are effential characters which difcriminate the animal from the vegetable.

But all animals are endowed with fenfation, or at leaft with irritability, which laft has been confidered as a diftinctive character of animal life. Senfation implies a diftinct perception of pleafure and pain. We infer the exiftence of fenfation in organized bodies, when we perceive that they have organs fimilar to our own, or when they act, in certain circumftances, in the fame manner as we act. If an organized being has eyes, ears, and a nofe, we naturally conclude that it enjoys the fame fenfations as thefe organs convey to us. If we fee another being, whofe ftructure exhibits nothing analogous to our organs of fenfation, contracting with rapidity when touched, directing its body uniformly to the light, feizing fmall infects with *tentacula*, or a kind of arms, and conveying them into an aperture placed at its anterior end, we hefitate not to pronounce that it is animated. Cut off its arms, deprive it of the faculty

culty of contracting and extending its body, the nature of this being will not be changed ; but we will be unable to determine whether it poſſeſſes any portion of life. This is nearly the condition of the ſmall ſections of a polypus, before their heads begin to grow. The wheel-animal, the eels in blighted wheat, and the ſnails recorded in the Philoſophical Tranſactions, afford inſtances of every appearance of ſenſation, or even of irritability, being ſuſpended, not for months, but for ſeveral years, and yet the life of theſe animals is not extinguiſhed; for they uniformly revive upon a proper application of moiſture.

Theſe and ſimilar facts ſhow, that we are entirely ignorant of the eſſence and properties of life. What life really is, ſeems too ſubtile for our underſtanding to conceive, or our ſenſes to diſcern. If we have no other criterions to diſtinguiſh life, than motion, ſenſation, and irritability, the animals juſt mentioned continued for years in a ſtate which every man would pronounce to have been perfectly dead. It is poſſible, therefore, that life may exiſt in many bodies which are commonly thought to be as inanimate as ſtones. Hence it would be raſh to exclude plants from every ſpecies of ſenſation. The degrees of ſenſation decreaſe imperceptibly from man to the ſea-nettle, gall-inſects, and what are called the moſt imperfect animals. Every vegetable, as well as the ſenſitive plant, ſhrinks when wounded. But, in moſt of them, the motion is too ſlow for our perception. When trees grow near a ditch, the roots which proceed in a direction that would neceſſarily bring them into the open air, inſtead of continuing this noxious progreſs, ſink below the level of the ditch, then ſhoot acroſs, and regain the ſoil on the oppoſite ſide. When a root is uncovered, without expoſing it to much heat, and a wet ſpunge is placed near it, but in a different direction from that in which the root is proceeding, in a ſhort time the root turns towards the ſpunge. In this manner the direction of roots may be varied at pleaſure. All plants make the ſtrongeſt efforts, by inclining, turning, and even twiſting their ſtems and branches, to eſcape from darkneſs and ſhade, and to procure the influences of the ſun. Place a wet ſpunge under the leaves of a tree, they ſoon bend downward, and endeavour to apply their inferior ſurfaces to the ſpunge. If a veſſel of water be placed within ſix inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never ſtops till it comes into contact with the water. When a pole is placed at a conſiderable diſtance from an unſupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a ſhort time, it alters its courſe, and ſtops not till it clings around the pole.

Facts of this kind excite our wonder; but they by no means prove that vegetables live, or that they are endowed with ſenſation, which implies a diſtinct perception of pleaſure and pain.

There is an inferior ſpecies of ſenſation, which is diſtinguiſhed by the term *irritability*. This term denotes that power by which muſcular fibres, even after they are detached from the body, contract upon the application of any ſtimulating ſubſtance, whether ſolid or fluid. The heart of a frog, when pricked with the point of a pin, continues to beat, or to contract and dilate, for ſeveral hours after it has been cut out of the animal's body. The heart of a viper, or of a turtle, beats diſtinctly from twenty to thirty hours after the death of theſe animals. The periſtaltic motion of the inteſtines is produced by their irritability. When the inteſtines of a dog, or any other quadruped, are ſuddenly cut into different portions, all theſe portions crawl about like worms, and contract upon the ſlighteſt touch. Though irritability be unqueſtionably a vital principle, yet it is equally certain, that muſcular fibres, when ſeparated

rated from the body to which they belong, have no diftinct perception of pleafure or pain. Their regular contraction and dilatation are evident fymptoms of life, which, in many cafes, may lead us to attribute living powers to fubftances that enjoy neither life nor fenfation. Hence, though all plants were irritable, this circumftance would not prove that they are poffeffed of life. The contraction and dilatation of the fenfitive plants, and the various motions of the leaves, branches, flowers, and roots of vegetables formerly mentioned, feem to indicate that moft plants are endowed with irritability. Perhaps all vegetables have more or lefs of this quality. The heart, inteftines, and diaphragm, are the moft irritable parts of animal bodies: And, to difcover whether this quality refides in all plants, experiments fhould be made chiefly on their leaves, flowers, buds, and the tender fibres of the roots.

From this narration of facts, it appears, that plants make a very near approach to animals; and that this fimilarity, as well as the difficulty of fixing the precife boundaries by which thefe two great kingdoms of nature are limited, are direct confequences of the organization of vegetables. It is owing to their organic ftructure alone, that plants and animals are capable of affording reciprocal nourifhment to each other. This organic ftructure, though greatly diverfified in the different fpecies of animals and vegetables, evinces that Nature, in the formation of both, has acted upon the fame general plan. May we not prefume, therefore, as plants as well as animals are compofed of a regular fyftem of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings? I mean not to infinuate, that plants can perceive pleafure or pain. But, as many of their motions and affections cannot be explained upon any principle of mechanifm, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleafure and pain, is the principle that regulates all the vital or involuntary motions of animals. To afcertain this point, would require a fet of very nice experiments. I fhall mention one, which might be performed with tolerable eafe. It was formerly remarked, that plants kept in a hot-houfe, where the degree of heat is uniform, never fail to fleep during the night. This is direct evidence, that heat alone is not the caufe of their vigilance. But they are deprived of light. Let, therefore, a ftrong artificial light, without increafing the heat, be thrown upon them. If, notwithftanding this light, the plants are not roufed, but continue to fleep as ufual, then it may be prefumed that their organs, like thofe of animals, are not only irritable, but require the reparation of fome invigorating influence which they have loft while awake, by the agitations of the air and the fun's rays, by the act of growing, or by fome other latent caufe.

It is almoft unneceffary to mark the diftinction between vegetables and minerals. The tranfition from the animal to the plant is effected by fhades fo imperceptible, as to elude the moft acute obfervers. But, between the plant and the mineral, there is a vaft chafm in the chain of being, which may be the fource of great difcoveries. In bodies purely mineral, not a veftige of organization can be difcovered. The fibrous ftructure of the afbeftos has been regarded as an approach toward organization, and as the link which connects the mineral to the vegetable kingdom. But this is one of thofe ftrained analogies which are too often employed by theoretical writers. Though the afbeftos is compofed of a kind of threads or fibres, thefe fibres are not tubular; neither are they interwoven, like that regular tiffue or fabric which fo remarkably diftinguifhes organized from brute matter. Of courfe, the magnitude of the afbeftos can only be increafed by the appofition of new matter, and not by any developement or expanfion of parts. But though, in the

the mineral kingdom, Nature ceafes to organize, fhe continues to arrange.

The regular configuration of falts, cryftals, and other precious ftones, has been confidered by fome authors as the refult of an organic procefs. But the uniform figure of falts and chryftals may be the effect of certain laws of attraction peculiar to each fpecies. None of thefe particles can be regarded as a germ or bud. They are only the elements or conftituent parts, which, when applied to each other, form a whole. They never expand or grow, like the embrios of animals or plants. They remain for ever in the fame ftate without diminution or increafe, except when feparated by force, or magnified by an accumulation of frefh matter. The chryftalline juice is not affimulated by veffels : It is prepared by a chymical operation of Nature. The bodies of plants and animals are machines, exceedingly elaborate, and more or lefs complicated. Thefe machines, by means of different organs, have the power of converting other animals and vegetables into their own fubftance. By this affimulation, all their dimenfions are increafed ; and their various parts uniformly preferve the fame proportions with regard to each other, and continue to perform their refpective functions. Befides, organized bodies not only multiply their fpecies, but fome of them poffefs the power of reproducing fuch parts as are forcibly abftracted from them.

In thefe and many other qualities common to the animal and vegetable, there is not the fmalleft analogy to be found in the mineral kingdom. Between the moft regular foffils, as falts and chryftals, and the moft imperfect animal or vegetable, the diftance is immenfe. Figured foffils are not more organized than a column or a portico. In the formation of the former, Nature, in that of the latter, man, is the artift. When no fimilarity is to be difcovered in thofe fofſils which are nearly uniform in their configuration, we are not to expect it in the more looſe and irregular parts of brute matter. Here, Nature, regardleſs of ſymmetry, conjoins heterogeneous materials, of which ſhe compoſes irregular maſſes. Many ſtones, flints, and other concretions, afford examples of this kind. More art, it muſt be acknowledged, appears in the formation of metals: But their ſtructure exhibits no veſtiges of organization.

ANALOGIES.

HAVING ſhown the extreme difficulty of fixing the boundaries which ſeparate the animal from the vegetable kingdom, I proceed to the more pleaſing taſk of enumerating ſome of thoſe beautiful analogies which ſubſiſt between them. To render this ſubject the more agreeable and inſtructive, inſtead of bringing together an unconnected maſs, I ſhall trace the analogies between the animal and plant, under the arrangement of *Structure and Organs*, *Growth and Nouriſhment*, *Diſſemination and Decay*.

STRUCTURE AND ORGANS.

IN all organized bodies, a ſimilarity of ſtructure ſeems to be unavoidable. The bodies of men and quadrupeds conſiſt of a ſeries of connected bones, which run from the head to the rump. This ſeries is known by the name of the *back-bone*, from each ſide of which, a number of arched bones proceed. Some of theſe join the breaſt-bone by means of cartilages, and form a vaulted cavity, which contains and defends the heart, and other viſcera proper to the cheſt.

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The bones of the pelvis, and of the four extremities, are joined to the back-bones by articulations and membranes. By the ſame contrivance, the cranium is fixed to the upper end of the back-bones. Into different proceſſes and portions of all theſe bones, a great number of muſcles, or bundles of fleſhy fibres, are inſerted. Theſe muſcles are the inſtruments which give riſe to all the varieties of animal motion. The bones of the head, or cranium, contain the brain and cerebellum, a prolongation of which runs through the whole extent of the canal in the back-bone, and is known by the term *ſpinal marrow*. From the brain and ſpinal marrow proceed all the nerves, or inſtruments of ſenſation. Theſe nerves, the ramifications of which are infinitely various and minute, are diſtributed upon the heart, lungs, blood-veſſels, bowels, and muſcles, till they terminate on the ſkin, or external covering of the body. The heart is the fountain, or general receptacle of the blood. The contraction of the heart propels the blood through the arteries, which are likewiſe diſtributed, by numerous and complicated ramifications, over every part of the body, and terminate in the veins, which again collect the whole arterial blood into one cavity, and reconvey it to the heart. This circulatory proceſs goes on during life.

Beſide the organs already mentioned, there are others, termed *ſecretory*, becauſe they ſeparate peculiar fluids from the general maſs of circulating blood. The ſtomach and inteſtines are furniſhed with a vaſt number of ſmall tubes, called *lacteal ducts*, which ſeparate and abſorb the nutritious parts of the aliment, and reject all the groſſer and uſeleſs particles. Theſe ducts, after innumerable communications with each other, unite into one large tube, diſtinguiſhed by the name of the *thoracic duct*, which is the general reſervoir of the chyle, or ſecreted liquor. This chyle, which is a mild fluid, paſſes from the thoracic duct to the ſubclavian vein; and by this vein it is conveyed to the heart, where it mingles with the

the blood, and is circulated through the body, for the nouriſhment of its different parts. It is of no moment, for our preſent purpoſe, to be more particular, eſpecially as this ſubject will be afterwards more fully handled. I ſhall therefore juſt mention, that there are particular organs or glands for ſecreting various fluids, which are neceſſary to the exiſtence of the larger animals, as the kidneys for the ſecretion of urine; the liver for the ſecretion of gall; the ſtomach for the ſecretion of the gaſtric juices; the ſalivary glands for the ſecretion of ſaliva, &c.

From this ſketch of the ſtructure of man and of quadrupeds, very little attention is neceſſary to perceive, that Nature purſues a ſimilar plan in the formation of birds and fiſhes.

In that numerous claſs of animals diſtinguiſhed by the name of *inſects*, there is a great variety of form and ſtructure. In many of theſe, Nature ſeems to depart from her general mode of operation. But, upon a more accurate examination, this ſeeming departure will appear to be only an extenſion of that univerſal plan which ſhe obſerves in the formation of all animated beings. Some inſects, the lobſter, and all the cruſtaceous and ſhell animals, have their bones on the outſide of their bodies. To theſe bones the muſcles and other inſtruments of motion are attached. Many ſpecies have no bones; but their bodies conſiſt of a ſucceſſion of rings incaſed into each other. By contracting and dilating theſe rings, all the movements of this kind are performed. The head, in ſome ſpecies, changes its form every moment. It contracts or dilates, appears or diſappears, at the pleaſure of the animal. Theſe motions are permitted by the flexibility of the membranes, or coverings of the head. In other ſpecies, the form of the head is permanent, owing to the hardneſs of the coverings, which are ſcaley or cruſtaceous, and approaches nearer to that of the more perfect animals.

Many insects are destitute of particular organs. Some want eyes, ears, brain, and nostrils. Other have an acute sense of smelling, though we know not the form or situation of the organ. The inferior species of insects have no internal lungs, but receive air by lateral pores, and sometimes by long tubes, or tracheae, which protrude from different parts of the body. Many insects have no heart, or general reservoir for the reception and propulsion of the blood. But we discover by the microscope, that their blood circulates by the pulsation of arteries, and that their different fluids are secreted by glands. In a word, Nature, in the structure and functions of animals, descends, by degrees almost imperceptible, from man to the polypus, a being which, ever since its oeconomy and properties were discovered by M. Trembley, has continued to astonish both philosophers and naturalists. The structure of the polypus, which inhabits fresh water pools and ditches, is extremely simple. Its body consists of a single tube, with long *tentacula*, or arms, at one extremity, by which it seizes small worms, and conveys them to its mouth. It has no proper head, heart, stomach, or intestines of any kind. This simplicity of structure gives rise to an equal simplicity in the oeconomy and functions of the animal. The polypus, though it has not the distinction of sex, is extremely prolific. When about to multiply, a small protuberance or bud appears on the surface of its body. This bud gradually swells and extends. It includes not a young polypus, but is the real animal in miniature, united to the mother as a sucker to the parent-tree. The food taken by the mother passes into the young by means of a communicating aperture. When the shooting polypus has acquired a certain growth, this aperture gradually closes, and the young drops off, to multiply its species in the same manner. As every part of a polypus is capable of sending off shoots, it often happens, that the young, before parting from the mother, begin to shoot; and the parent-animal carries several generations on her own body. There is another ſingularity in the hiſtory of the polypus. When cut to pieces in every direction fancy can ſuggeſt, it not only continues to exiſt, but each ſection ſoon becomes an animal of the ſame kind. What is ſtill more ſurpriſing, when inverted as a man inverts the finger of a glove, the polypus ſeems to have ſuffered no material injury ; for it ſoon begins to take food, and to perform every other natural function. Here we have a wonderful inſtance of animal ductility. No diviſion, however minute, can deprive theſe worms of life. What infallibly deſtroys other animals, ſerves only, in the polypus, to multiply the number of individuals. M. Trembley, in the courſe of his experiments, diſcovered, that different portions of one polypus could be ingrafted on another. Two tranſverſe ſections brought into contact quickly unite, and form one animal, though each ſection belongs to a different ſpecies. The head of one ſpecies may be ingrafted on the body of another. When a polypus is introduced by the tail into another's body, the two heads unite, and form one individual. Purſuing theſe ſtrange operations, M. Trembley gave ſcope to his fancy, and, by repeatedly ſplitting the head and part of the body, formed hydras more complicated than ever ſtruck the imagination of the moſt romantic fabuliſts.

This ſhort account of the general ſtructure of animals was a neceſſary preparation for perceiving more clearly their connection with the vegetable kingdom.

The ſtructure of plants, like that of animals, conſiſts of a ſeries of veſſels diſpoſed in a regular order. Theſe veſſels are deſtined to perform the different functions neceſſary to the nouriſhment, growth, and diſſemination of the plant. In trees, and moſt of the larger vegetables, three diſtinct parts are to be obſerved ; the bark, the wood, and the pith. The bark likewiſe conſiſts of three parts ; the

ſkin,

ſkin, the body, and the *liber*, or inner circle ; which laſt, about the end of autumn, aſſumes the ſame texture and firmneſs with the wood. The ſubſtance of the bark is compoſed of a number of longitudinal ſap and air veſſels, which have the appearance of fine threads, running from the root to the trunk and branches. Beſide theſe veſſels, the bark is furniſhed with a parenchymatous or pulpy ſubſtance, in which there are a vaſt variety of *folliculi*, or ſmall bladders. The bark is connected to the wood by tranſverſe inſertions of the parenchyma.

The wood conſiſts of two diſtinct ſubſtances ; the one is denſe, and compact, and conſtitutes what is termed the *ligneous body* ; the other is porous, moiſt, and pulpy, and is therefore called the *parenchymatous* part of the wood. A portion of wood is placed alternately between a ſimilar portion of parenchyma. Theſe alternate portions proceed from the edges of the pith, as *radii* from the center of a circle, widening proportionally as they approach the circumference. Both of them, however, like the bark, are furniſhed with numberleſs ſap and air veſſels.

The pith or heart is bounded on all ſides by the wood, and is compoſed of the ſame materials : It is nothing but a vaſt congeries of air and ſap veſſels, interwoven with the parenchyma and bladders, not unlike the tiſſue of gauze or lace. This texture is common to every part of the trunk, being only more cloſe and compact in the bark and wood than in the pith. It is well known, that the pith of plants diminiſhes in proportion to their age. The reaſon is obvious : Every year the ring of veſſels, which lies contiguous to the wood, dries, condenſes, and becomes wood.

The leaves of vegetables conſiſt of a fine ſkin, which incloſes the parenchyma or pulp. This ſkin, like that of animals, is an organic body, furniſhed with an immenſe number of parenchymatous and ligneous fibres, and interwoven in a manner preciſely ſimilar to that of the trunk and branches. When the ſkin is removed, the pulp appears, and is every where interſperſed with ſmall cylindrical fibres, wound up into minute bladders. A large nerve runs along the middle of every leaf, and continually ſends off branches, which gradually decreaſe in magnitude, till they reach the edge or diſc. This principal nerve is a collection of ſmall tubes, which, at proper diſtances, go off, and are diſtributed over the leaf in a manner preciſely ſimilar to the diſtribution of the nerves over the human body.

With regard to flowers and fruits, their general texture is the ſame with that of the parts already deſcribed, differing only in various proportions of the ligneous veſſels and parenchymatous or pulpy ſubſtance. That vegetables are poſſeſſed of ſecretory glands, is apparent from the almoſt infinite variety of their taſtes, odours, and colours. Theſe ſenſible qualities differ even in different parts of the ſame plant. But the glandular ſecretion of vegetables is moſt conſpicuous in the flowers and fruit. Many flowers ſecrete a nectareous fluid, which is more grateful to the palate than the fineſt honey. The glands of ſome fruits, as thoſe of the lemon and orange, ſecrete liquors of very different qualities. The veſſels of the rhind contain an acrid eſſential oil, while thoſe of the parenchyma or pulp ſecrete an agreeable acid.

This ſimilarity in the general ſtructure of animals and plants is ſtrongly corroborated by the analogous parts in both being deſtined to anſwer the ſame purpoſes.

The oeconomy and functions of vegetables, as well as thoſe of animals, are the reſults of a vaſcular texture. Each of theſe claſſes of of beings have veſſels deſtined to the performance of ſimilar offices. In man and quadrupeds, the fluids are circulated by the pulſation of the heart and arteries. The juices of plants do not circulate; but they are raiſed from the root to the trunk, branches, leaves, flowers, and fruit, by the ſap-veſſels. The aſcenſion of the ſap has been aſcribed to capillary attraction. But, though no motion is perceptible in the ſap-veſſels ſimilar to the pulſation of arteries; yet, both the propulſion of the ſap, which moves with great force, and the ſecretion of different fluids by different parts of the ſame plant, imply an action in theſe veſſels. In animals, the gall, the urine, the ſaliva, are all concocted from the general maſs of blood by the action of particular veſſels. Fluids of theſe different qualities exiſt not in the blood itſelf: They are created by an incomprehenſible operation of the veſſels peculiar to their reſpective glands. In plants, the ſap aſcends, and different fluids are ſecreted from it by glandular veſſels. Here the ſame effects are produced both in the animal and the plant. We muſt, therefore, attribute them to the ſame cauſe, namely, the action of veſſels. Beſides, the ſap, which is the blood of plants, moves with a force often equivalent to the weight of the atmoſphere. M. Bonnet remarks *, that he has ſeen, by means of coloured liquors, the vegetable ſap move three inches in an hour; and Dr Hales, in his Statics, has ſhown, that the leaves are the principal organs of tranſpiration. He likewiſe conſiders them to be the inſtruments which raiſe the ſap. But it has ſince been diſcovered, that coloured liquors riſe equally high in branches deprived of leaves, and that they do not riſe at all in dried plants. Hence the ſap of vegetables is not taken up in the ſame manner as a ſpunge imbibes water, but is forced to aſcend by an unknown action of the veſſels. The ſpring of the tracheae may put in motion the air they contain, and that air may have ſome influence on the general movement. But, by whatever powers the ſap

* Oeuvres, tom. 1. p. 140.

ſap is moved, the exiſtence of the motion is certain; and it is equally certain, that this movement of the ſap produces the ſame effects in the vegetable, that the force of the heart and arteries does in the animal.

The motion of the ſap, in vegetables, is not properly a circulation ſimilar to that of the blood in the more perfect animals. It aſcends and deſcends in the ſame veſſels; and theſe motions are evidently affected by heat and cold. The ſap riſes copiouſly in a warm day, and deſcends during the night, nearly in the ſame manner as the mercury riſes and falls in the thermometer. But, though the analogy here fails with regard to man and the larger animals, yet it holds in the taenia, the polypus, and many other inſects, which exhibit not the ſmalleſt veſtiges of circulation in their juices.

The pith, or medullary ſubſtance of plants, has ſome reſemblance to the brain and ſpinal-marrow of animals. When the texture of the brain or ſpinal-marrow is deſtroyed, life is extinguiſhed; and, when the pith of plants is deſtroyed or dried up by age, they no longer retain the power of vegetating. The leaves of plants are analogous to the lungs of animals. It is by the lungs that the perſpiration of animals is chiefly effected; and plants diſcharge moſt of their ſuperfluous moiſture by the leaves. They expoſe a large ſurface to the action of the ſun, which produces a tranſpiration ſo copious, that ſome plants throw out fifteen or twenty times more in a given period, than is diſcharged from the human body. When a plant is deprived of its leaves in ſummer, inſtead of ripening its fruit, it is in great danger of dying for want of thoſe organs which carry off the ſuperfluous juices that ariſe from the root. A plant, in this ſituation, may be conſidered as labouring under an aſthma, or dying of a ſuffocation.

Beſide the leaves, plants tranſpire by the pores of the ſkin. But the quantity emitted in this manner is not nearly equal to that which iſſues from the leaves. The ſame thing happens with regard to man and quadrupeds. Though they likewiſe perſpire through the ſkin, yet by much the greater quantity of perſpirable matter is diſcharged by the lungs. Beſide throwing out ſuperfluous or noxious matter by the leaves, plants, by the ſame organs, abſorb from the atmoſphere, and perhaps from the ſun's rays, ſome unknown matter, which is neceſſary to their exiſtence. The lungs of animals likewiſe derive, from the ſame ſources, a particular matter or principle, without which life could not long be continued.

Another analogy between the ſtructure of plants and animals merits obſervation. The round bones of animals conſiſt of concentric ſtrata or plates, which can be eaſily ſeparated ; and the wood of plants conſiſt of concentric layers of hardened veſſels, which ſeparate when macerated in water. A tree acquires an additional ring every year ; and, by counting theſe rings, a pretty exact eſtimation of its age may be attained.

The branches of plants have been conſidered as analogous to the arms or tentacula of animals. But this is one of thoſe ſtrained analogies which ſhould be carefully avoided. The great uſe of branches is evident. By producing an amaſing number of leaves, a large ſurface is expoſed to the air and ſun, to anſwer the important purpoſes of tranſpiration and abſorption. If there is any thing in plants analogous to the arms or tentacula of animals, it muſt be confined to ſuch ſpecies as twiſt themſelves around poles or trees, as the ivy, the vine, the convolvulus, &c. and to ſuch as ſupport their trunks on other bodies by means of little hooks, as the gooſe-graſs, and many other kinds.

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All thefe analogies, it may be remarked, are confined to large animals and large vegetables; but they hold not in that numerous tribe of plants called *graffes*. Inftead of being filled with wood and pith, their ftems are perfectly hollow; and, to fortify thefe plants, Nature has beftowed on them ftrong joints or knots, which are placed at regular diftances in each fpecies. But, though fome of the analogies which fubfift between the larger animals and vegetables exift not in the fmaller plants, this circumftance, inftead of infringing, confirms the general plan of Nature. To difcover the analogies between tubular plants and animals, we muft examine the ftructure of the minuter tribes of animated beings. The graffes have neither pith nor wood internally; and the polypus, the taenia, and many other infects, have no bones, heart, or inteftines, but are fimple tubes, perfectly refembling the empty ftems of the gramineous plants. Befides, the ligneous, or at leaft the herbaceous part of thefe plants, is placed on the outfide, fimilar to the cruftaceous and fhell animals, whofe bones are fituated externally. Another analogy muft not be omitted. The fucculent vegetables, fuch as the houfe-leek, the mufhroom tribes, and many fea-plants, confift almoft entirely of a pulpy or parenchymatous fubftance, and may be crufhed to a jelly by the flighteft preffure. The texture of worms, caterpillars, and of all the foft infects, is extremely fimilar to that of the fucculent vegetables.

II.—GROWTH AND NOURISHMENT.

THE fecond fource of analogies between the plant and animal is derived from the modes of their growth and nourifhment.

Many ingenious theories have been invented, with a view to explain the myfterious operation by which the growth and nourifhment of animals and vegetables are effected. But I ſhall confine myſelf, at preſent, to ſuch remarks as are purely analogical, and may be fully underſtood without a minute knowledge of the different ways by which growth and nouriſhment have been ſuppoſed to be accompliſhed.

Animals, like vegetables, gradually expand from an embryo or gelatinous ſtate, and, according to their kinds, arrive ſooner or later at perfection. This expanſion and augmentation of ſubſtance is the idea conveyed by the word *growth*. Without ſome nutritious matter taken into the body, and aſſimilated, by the action of veſſels, to the ſubſtance of the being that receives it, growth cannot take place. Moiſture is the chief food of plants. But the food of animals, in general, varies with the ſpecies. This fact led ſome philoſophers to conclude, that every plant extracted from the ſoil a food peculiar to its own nature. It was, however, afterwards diſcovered, by repeated experiments, that vegetables can grow, and acquire a very conſiderable degree of bulk and weight, without exhauſting a perceptible quantity of the earth in which they are planted. Theſe experiments are a ſufficient proof, that moiſture conſtitutes the chief nouriſhment of plants. They likewiſe indicate, that vegetables, however diverſified in their figure, denſity, and fibrous arrangement, are more ſimple in their texture than animals. But, notwithſtanding theſe ſeeming differences in the nouriſhment of plants and animals, Nature fails not to obſerve the ſame courſe in both kingdoms. The food of the animal, before it is converted into nouriſhment, muſt go through the intricate proceſs of digeſtion. But, after the food has been converted into chyle, and the chyle into blood, this blood becomes a common fluid, from which all nouriſhment and all animal fluids are derived. Here the analogy is apparent. Moiſture is to the plant preciſely what blood is to the animal. Each of them extracts its nouriſhment from a common fluid; and,

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in both, this fluid is changed, by the action of veſſels, into the various juices peculiar to the different ſpecies.

When growth firſt commences, the embryos of plants and animals are in ſimilar circumſtances. Soon after conception, the foetus is incloſed in its membranes, and is nouriſhed, till mature for birth, by blood which it receives from the uterus and placenta. In the ſame manner, the embryo of a plant is incloſed in the membranes of the ſeed; and its fibrous roots are ſpread over the lobes or pulpy part. After the ſeed is ſown, and vegetation commences, the embryo is nouriſhed by moiſture, which the lobes abſorb from the earth, and convey it to the minute tubes of the ſeminal root. In many plants, theſe lobes riſe above the ſurface of the ground, in the form of leaves, and continue to nouriſh and protect the tender plume or ſtem, till it acquires ſtrength ſufficient to ſupport the aſſaults of the air and weather. A plant, in this ſituation, may be ſaid to have two roots; one, the fibres of which are diffuſed through the ſubſtance of the lobes, or ſeminal leaves, and another attached to the ſoil.

The nouriſhment thus conveyed to vegetables by the ſeminal leaves, is extremely analogous to that of animals by the milk of the mother. The texture of young animals is ſo lax and unelaſtic, that the food ſuited to maturer years would ſoon put a period to their exiſtence. But Nature has provided againſt this inconveniency. She has endowed females with a ſet of veſſels deſtined for the ſecretion of a mild liquor, ſo far concocted and animalized as to be adapted to the tender and flaccid condition of their young. A ſimilar proviſion of nouriſhment is afforded to the young vegetable. For ſome time after the plume and radicle have begun to ſhoot, their texture is ſo extremely tender, that they are unable to ſupport each other without ſome foreign aid. This aid is afforded them by

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the ſeminal leaves. Theſe leaves abſorb dews, air, and other fine fluids, which are concocted and aſſimilated in the veſſels of the ſeminal root, and then conveyed, in a kind of vegetable form, to the feeble veſſels of the plume. Hence it is apparent, that the nouriſhing of young animals by milk, and of young vegetables by ſeminal leaves, is the ſame inſtitution of Nature, and effected by ſimilar inſtruments.

Plants, like animals, paſs gradually from an embryo, or infant ſtate, to that of puberty. At this period of their exiſtence, they have acquired that firmneſs of texture, and that evolution of parts, which conſtitute the perfection of their natures, and enable them to produce beings every way ſimilar to themſelves. In both kingdoms, the age of puberty arrives later or more early, according to the difference of ſpecies. Some animals live a few months only. Many of the inſect tribes are produced, grow to maturity, propagate their kind, and die in the courſe of a ſingle ſeaſon. Others, as ſeveral flies, beetles, &c. exiſt two years. Thus animals have a progreſſive duration of life. The dormouſe lives ſix years, the hare ſeven or eight, the bear twenty or twenty-five, the camel forty or fifty, the rhinoceros ſeventy or eighty, the elephant two hundred; and ſome birds and fiſhes are ſuppoſed to exiſt during three or four centuries. The ſame progreſſive duration takes place among vegetables. Some plants are annual, as moſt of the eſculent kinds; others, as the hedge-parſley, the wild carrot, the parſnip, the fox-glove, the ſcurvy-graſs, &c. are biennial; others exiſt three, five, ſeven, ten, twenty, thirty, ſixty, and a hundred years; and the oak, like the elephant and thoſe birds and fiſhes which are famed for longevity, continues to adorn the foreſt for ſeveral centuries.

The manner by which the nutritious particles are extracted from food, is very ſimilar in the animal and the plant. In the animal, this operation is performed by the lacteal veſſels, which are diſtributed over the internal ſurface of the ſtomach and inteſtines. In the plant, the ſame office is performed by the veſſels of the root and leaves. Hence animals are organized beings nouriſhed by roots ſituated within their bodies ; and plants are organized bodies which abſorb their nouriſhment by roots placed externally. Beſides, in all viviparous animals, the foetus is nouriſhed, not by food taken in at the mouth, but by veſſels attached to the placenta. Theſe veſſels perform the ſame office to the foetus, that roots do to vegetables.

Warmth and moiſture are favourable to the production of large and juicy plants ; and the animals that feed upon theſe ſucculent and rich vegetables, are likewiſe larger than thoſe which inhabit cold countries, where the plants are ſmaller, more rigid, and contain fewer nutritive particles.

Some plants grow in particular climates only. The *rubus arcticus*, a ſpecies of bramble, ſo common in Norway and Canada, hardly endures the climate of Upſal, in Sweden. But the *alſine media*, or chickweed, and ſeveral graſſes, are diffuſed over almoſt the whole globe. In the ſame manner, ſome animals, as the camel, the rhinoceros, and the elephant, are produced in warm climates only ; while others, as the rein-deer, glutton, and marmot, are confined to the colder regions of the earth ; and man, in the animal, like ſome graſſes in the vegetable kingdom, is univerſal, and inhabits every climate.

Some plants, as well as ſome animals, are amphibious, as the ruſh and the frog ; others are paraſites, and feed on the juices they extract from different ſpecies to which they adhere. The miſſeltoe, for example, feeds upon the oak; moſt trees afford nouriſhment to certain moſſes and fungous plants; and every animal is fed upon by ſmaller kinds.

The growth of plants, like that of animals, may be accelerated or retarded by promoting or checking their perſpiration, and by excluding them from proper exerciſe and air. When men, or other animals, are confined to ſituations which prevent the free acceſs of pure air, their growth is retarded; and their ſickly colour indicates a defect of vigour. Plants, when placed in ſimilar circumſtances, are always weak, dwarfiſh, and unnaturally coloured. But exerciſe is equally neceſſary to the health and vigour of plants, as it is to thoſe of animals. The exerciſe of animals is effected by various kinds of ſpontaneous motion. Plants are likewiſe exerciſed by motion; but that motion is not voluntary: It is communicated to them by the action of the air. The agitation which they receive from the winds enables them to extend their roots, prevents them from a growth too rapid, and, of courſe, ſtrengthens their whole fabric. It is owing to the want of this agitation, that plants brought up in houſes, or in other confined ſituations, ſhoot out to an unnatural length; that their ſtems and branches are always ſlender and weak; and that they ripen not their fruit like thoſe which are expoſed to the open air.

To conclude this branch of the ſubject, plants and animals are ſo nearly allied, that their growth and nouriſhment are not only effected by ſimilar inſtruments, but ſome parts of animal bodies evidently partake of a vegetable nature. Thus, the hairs, the nails, the beaks, and the horns, are a ſpecies of vegetables, as appears from their comparative total inſenſibility, as well as from the mode of their growth and reproduction.

III.—DISSEMINATION AND DECAY.

WE ſhall next take an analogical view of the diſſemination and decay of the animal and vegetable.

The power of reproduction is peculiar to the plant and animal. Each of them is capable of producing beings every way ſimilar to the parent. But the modes by which this ſingular effect is accompliſhed, are very different in appearance. It is our preſent purpoſe to remove this apparent difference, and to ſhow that animals and vegetables multiply their ſpecies in a manner extremely analogous.

Animals have long been divided into viviparous and oviparous. The one claſs produce their young alive, the other lay eggs, which muſt be hatched either by the heat of the ſun, or by that of the mother. This diviſion, though very comprehenſive, is not perfect. Several animals have lately been diſcovered which are neither viviparous nor oviparous; and there are animals which unite both theſe modes of multiplication.

The viviparous claſs comprehends men, quadrupeds, and ſome fiſhes, reptiles, and inſects. The oviparous includes birds, ſome reptiles, and moſt of the inſect tribes. But the armed polypus, or *hydra* of Linnaeus, inſtead of being either viviparous or oviparous, multiplies its ſpecies, as formerly remarked, by ſending off ſhoots from the body of the parent.

Another ſpecies, called the *bell-polypus*, or *hydra ſtentorea* of Linnaeus, multiplies by ſplitting longitudinally. In twenty-four hours, theſe diviſions, which adhere to a common pedicle, reſplit, and form

form four diftinct animals. Thefe four, in an equal time, again fplit; and thus they proceed doubling their numbers daily, till they acquire a figure fomewhat refembling a nofegay. The young afterwards feparate from the parent ftock, attach themfelves to the roots or leaves of aquatic plants, and each individual gives rife to a new colony.

The funnel-fhaped polypus multiplies by fplitting tranfverfely. Of the individuals, accordingly, which proceed from this divifion, one has the old head and a new tail, and the other a new head and the old tail. The fuperior divifion fwims off, and fixes itfelf to fome other fubftance; but the inferior divifion remains attached to the former pedicle.

The dart-millepes affords another example of multiplication by fpontaneous feparation. This infect divides, about two-thirds below the head, into two diftinct and perfect animals; and it feems to poffefs no other mode of continuing the fpecies.

The multiplication of the various animalcules which appear in infufions of animal and vegetable fubftances, long occupied the attention, and eluded the refearches of philofophers. This difcovery of the increafe of fome larger animals by fpontaneous divifion, gave rife to the conjecture, that thefe microfcopic animalcules might multiply their numbers in a fimilar manner. This conjecture was communicated to M. de Sauffure in a letter from Bonnet, who received an anfwer, dated at Genoa, September 28. 1769, to the following purpofe.

'What you propofe as a doubt,' fays M. de Sauffure, 'I have 'verified by inconteftible experiments, namely, that infufion-ani'malcules multiply by continued divifions and fubdivifions. Thofe 'roundiſh or oval animalcules that have no beak or hook on the 'fore part of their bodies, divide tranſverſely. A kind of ſtricture 'or ſtrangulation begins about the middle of the body, which gra- 'gually increaſes, till the two parts adhere by a ſmall thread only. 'Then both parts make repeated efforts, till the diviſion is com- 'pleted. For ſome time after ſeparation, the two animals remain 'in a ſeemingly torpid ſtate. They afterwards begin to ſwim about 'briſkly. Each part is only one half the ſize of the whole: But 'they ſoon acquire the magnitude peculiar to the ſpecies, and mul- 'tiply by ſimilar diviſions.'——'To obviate every doubt,' continues our author, 'I put a ſingle animalcule into a drop of water, 'which ſplit before my eyes. Next day, I had five, the day after, 'ſixty, and, on the third day, their number was ſo great, that it 'was impoſſible to count them *.

'Another ſpecies, with a beak or horn on the fore part of its 'body, which I obtained from an infuſion of hemp-ſeed, multi- 'plied likewiſe by diviſion, but in a manner ſtill more ſingular 'than the former. This animalcule, when about to divide, at- 'taches itſelf to the bottom of the infuſion, contracts its body, 'which is naturally oblong, into a ſpherical form, ſo that the beak 'entirely diſappears. It then begins to move briſkly round, ſome- 'times from right to left, and ſometimes from left to right, the 'centre of motion being always fixed. Towards the end, its mo- 'tion accelerates, and, inſtead of a uniform ſphere, two croſs-like 'diviſions begin to appear. Soon after, the creature is greatly agi- 'tated, and ſplits into four animalcules perfectly ſimilar, though 'ſmaller than that from which they were produced. Theſe four 'increaſe to the uſual ſize, and each, in its turn, ſubdivides into 'other four †,' &c.

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* La Palingeneſie Philoſophique, par C. Bonnet, tom. 1. p. 428. 429.

† Idem, p. 430.

The beauties of Nature have been juſtly celebrated in the uniformity of her productions. This uniformity was early remarked, and gave riſe to the ancient diviſion of animals into viviparous and oviparous, which continued to be adopted as an univerſal maxim till within theſe hundred years. Before this period, it was believed by philoſophers, that all animals were either brought forth alive, or hatched from eggs. Among the ancients, indeed, and even down to the time of the celebrated Redi, this maxim included chiefly the more perfect animals; for, with regard to moſt of the inſect tribes, they imagined that theſe were produced by putrefaction, and the admixture of particular kinds of matter. But Redi, by a ſeries of unqueſtionable experiments, exploded the doctrine of the equivocal generation of inſects; and then the maxim, without farther inveſtigation, was extended to the whole animal kingdom. Redi's experiments and remarks turned the attention of philoſophers to the minuter tribes of animals. In the courſe of a few years, accordingly, ſeveral eminent men aroſe. Reaumur, Bonnet, Trembley, Ellis, Spalanzani, and a multitude of other writers, opened new views with regard to the manners and oeconomy of animated beings. M. Bonnet has furniſhed inconteſtible evidence, that ſeveral ſpecies of the puceron, or vine-fretter, are both oviparous and viviparous. In ſummer, theſe inſects bring forth their young alive; but, in autumn, they depoſit eggs upon the bark and branches of trees. Here the intention of Nature is apparent. The puceron is unable to ſurvive the winter colds; and, therefore, though viviparous during the warm months, the ſpecies could not be continued without this wiſe proviſion. The puceron, it ſhould appear, is naturally diſpoſed to produce live young. The foetus is incloſed in a membrane, which, like that of the larger animals, burſts before excluſion. But, when the cold ſeaſon commences, the general texture of the animals, as

* Traité d'Inſectologie, par C. Bonnet, tom. 1. p. 194.—202.

well as of the membranes inclosing the foetus, becomes more firm and tenacious; and this, perhaps, is the physical reason why they are viviparous in summer, and oviparous in autumn. Many other flies are known to be viviparous. Upon farther examination, all these will probably be discovered to be also oviparous *.

The puceron exhibits another phaenomenon still more singular. The maxim, that multiplication presupposed impregnation by sexual embraces, was formerly thought to be universal. Neither should the reception of this maxim be regarded as a matter of wonder; for it was founded on a very general and strong analogy. But the following facts show, that Nature, though uniform in many steps of her progress, is not invariably limited to the same mode of operation.

On the 20th day of May, M. Bonnet took a young puceron, the moment after dropping from the womb of its mother, and shut it up in a glass vessel, to prevent all possibility of communication with any individual of the species. A sprig of the tree on which the animal was produced, supplied it with nourishment. The creature changed its skin four times, namely, on the 23d, 26th, 29th, and 31st days of the same month. After a minute detail of circumstances, M. Bonnet informs us, that his imprisoned puceron grew with rapidity; that, on the 1st day of June, it brought forth; and that, from this day to the 21st, it produced no less than 95 young, all full of life and vigour †. He frequently repeated this experiment, and it was always followed with the same event.

M. Bonnet, suspecting that a single impregnation might influence both the mother and her immediate offspring, resolved to obviate

* See Reaumur, tom. 8. edit. 12mo, p. 153. *et seq.*

† Bonnet, Traité d'Insectologie, tom. 1. p. 39.; and Reaumur, tom. 12. p. 353.

viate every difficulty. For this purpofe, he confined, in feparate glaffes, the young of fucceffive births, as they dropped from their mothers. Each of thefe, however, were equally fertile, though he continued the experiment to the ninth generation from the original parent *.

Facts of this kind, which feem to interrupt the ordinary current of Nature, fhould infpire philofophers with caution. They fhould create reverence for fuch of her operations as are already known; but they fhould likewife check that rafh fpirit which too frequently draws unlimited conclufions, before the fubject be fully inveftigated. Of all inductions regarding the hiftory of Nature, the neceffity of fexual commerce for multiplying the fpecies appeared to be the moft general and the moft legitimate. The oeconomy of the puceron, however, demonftrates, that even this law is not indifpenfable, and that Nature has the power of changing her fteps, and of accomplifhing the fame purpofes by various means.

Having enumerated the different modes by which animals multiply their fpecies, I fhall next fhow, that the multiplication of vegetables is extremely analogous.

The viviparous, as well as the oviparous animals, are fuppofed to proceed from eggs, with this difference, that the young of the viviparous are hatched in the uterus previous to their exclufion.

Many ftriking analogies fubfift between the eggs of animals and the feeds of plants. When placed in proper circumftances, they both produce young every way fimilar to the parents. To accomplifh this wonderful effect, the egg requires impregnation and heat.

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* Bonnet, Traité d'Infectologie, tom. 1. p. 74. *et feq.*

Moiſture, warmth, and ſoil, or ſome ſimilar matrix, are neceſſary for the excluſion of the young plant. This analogy has been extended much farther by Linnaeus, and other ſupporters of the ſexual ſyſtem of plants. They maintain, that impregnation is equally indiſpenſable to the vegetation of the ſeed, as to the fertility of the egg. But, as this doctrine will be diſcuſſed when we come to treat of ſexes in general, we ſhall here diſmiſs it without farther remark.

Eggs are not only analogous to ſeeds, in their general deſtination of reproducing individuals, and continuing the ſpecies, but there is a great ſimilarity in the ſtructure and uſes of their reſpective organs.

The internal parts of the egg are covered with a cruſt or ſhell, and two membranes. Beſide theſe, the yoke is included in a ſeparate membrane. When the two firſt membranes are removed, the white appears every way inveſting the yoke. In the white, or rather on the membrane of the yoke, a ſmall cicatrice is diſcernible, in the centre of which is the *punctum ſaliens*, or embryo of the future animal. After two or three days incubation, this *punctum ſaliens* becomes red, and ſhoots out blood-veſſels, which are diſperſed through the yoke, in the ſame manner as the veſſels of a foetus are diſtributed over the placenta.

A ſeed is likewiſe covered with a ſhell, or cruſtaceous membrane. Another membrane inveſts the whole kernel, or pulpy lobes of the ſeed. Each lobe, like the yoke of the egg, is involved in a ſeparate membrane. In every ſeed there is alſo a ſmall cicatrice, or aperture, through which the young plant iſſues. Immediately under this cicatrice, the plume, or future plant, is diſcernible, reſembling the *punctum ſaliens* of the egg. The branches of the radicle proceed from this plume, and are diſperſed through the ſubſtance of the lobes, in the ſame manner as the blood-veſſels iſſue from the *punc-*

tum ſaliens of the egg, and are diſtributed over the yoke. It is by the pulp of the lobes that the radicle and plume are nouriſhed, till the one ſhoots down into the ſoil, and the other mounts above the ſurface. In ſeeds, there is nothing analogous to the white of an egg. Such a proviſion would have been ſuperfluous; for the earth, in which the ſeeds are to germinate, muſt always be moiſt, otherwiſe the young plant could not receive nouriſhment, after iſſuing from the ſeed. Beſides, the eggs of fiſhes have no white, becauſe they are perpetually moiſtened with water.

The analogies ariſing from the multiplication of animals and plants, by means of eggs and ſeeds, are the moſt common, and the moſt obvious. Eggs and ſeeds are evidently organs formed on the ſame plan, and deſtined by Nature to anſwer the ſame general intention: But the multiplication of plants, as well as that of animals, is not confined ſolely to one mode.

The young of viviparous animals, though they probably originate from ſmall eggs, are not brought forth till they have acquired a certain age and firmneſs of texture. It may be thought, that there is no multiplication of plants which has any reſemblance to that of viviparous animals. We ſhould reflect, however, that plants can multiply by buds. Now, a bud has no analogy, either in texture or appearance, to a ſeed. Buds ariſe from the ſtems or branches of vegetables. One object in their formation is to produce leaves and branches, as well as to extend the length of the trunk or ſtem. But they are likewiſe endowed with the faculty of reproducing new individuals. In this reſpect, trees and ſhrubs may be conſidered as viviparous plants; becauſe they produce out of their own bodies an organ, which, though differing in every view from a ſeed, is brought forth alive, and, when properly cheriſhed, is converted into a being perfectly ſimilar to the parent, and capable

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of continuing its ſpecies. The embryo of a bud commences its exiſtence under the bark. Here it remains, for ſome time, incloſed in membranous coverings, and attached to the bark by minute fibres, which convey to it a nouriſhment ſuited to its condition. When arrived at a certain ſize and conſiſtence, it pierces the bark, and ſhoots out into the open air. If allowed to remain on the parent, it ſoon burſts through its membranes, and, in time, gives riſe to a new branch: But, when detached from the parent, and placed in proper circumſtances, it becomes a new individual of the ſame ſpecies.

Bulbous rooted plants furniſh a ſtill ſtronger analogy between the increaſe of viviparous animals and that of vegetables. In the end of autumn, if the coats of any bulbous root be carefully diſſected, the entire plant in miniature will appear in the centre of the root. In ſpring, this ſmall plant, like a foetus incloſed in the uterus, pierces the coats of which the root conſiſts, and gradually grows till it flowers, ripens its ſeeds, and dies at the approach of winter, when a new plant is again formed in the old root. Here we have an example of the multiplication of plants ſimilar to that of the puceron; but the order of time is reverſed. The puceron is viviparous in ſummer, and oviparous in autumn; but bulbous-rooted plants may be conſidered as oviparous in ſummer, and viviparous in autumn.

The ſame analogy is to be traced in thoſe roots which have what are called *eyes*, like the potatoe. Theſe eyes are all plants in miniature, which live in that ſtate during the winter, and, when committed to the ſoil, come to maturity in ſummer.

There are ſtill other modes of multiplying common to the animal and vegetable. Many plants are multiplied by ſuckers, ſlips, and cuttings.

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The animal kingdom furniſhes examples of all theſe modes of multiplication. The ſuckers of plants have an exact analogy to the ſhoots of a polypus. When ſeparated from the parent, the ſucker becomes a perfect plant, and the ſhoot of the polypus a perfect animal. Plants are capable of multiplication by ſlips and cuttings: And the portions of a polypus, however ſmall, or when cut in any direction, reproduce, and become perfect animals of the ſame ſpecies.

But ſome ſpecies of the polypus, the dart-millepes, and ſeveral animalcules which appear in infuſions of animal and vegetable ſubſtances, multiply by ſplitting, or ſpontaneous ſeparation. Here the analogy between the animal and vegetable might be ſuppoſed to fail. The water-lentil, however, a ſmall plant, which covers the ſurface of ſtagnating pools, multiplies its ſpecies by detaching thin films from the under ſide of the leaf. Theſe films or tender leaves produce roots, and vegetate into a regular plant.

We muſt not diſmiſs this ſubject till another analogy be unfolded. All animals have ſeaſons peculiar to their reſpective kinds. Some of the larger animals produce in the ſpring, others in ſummer, others in autumn, and others in winter. With regard to the inſect tribes, their ſeaſons are ſtill more various. Every month, every week of the year, gives birth to different ſpecies. The ſeaſons of plants are diverſified in a ſimilar manner. The growth of different vegetables is diſtributed over the whole year. Particular tribes ſpring up at the ſame uniform periods. In this beautiful diverſity of arrangement, the intentions of Nature are evident. If all plants were to ruſh forward at the ſame time, they would infallibly choke each other. The ſurface of the earth could not afford them room. Nature has therefore wiſely ordained, that the earth ſhould always be covered with plants: But ſhe has alſo ordained, that particular tribes ſhould die at ftated periods, to make way for the exiftence of others. The fame inconvenience would happen, if the production of all animals, and particularly that vaft number of fpecies, and that immenfe profufion of individuals, to which the infect tribes give birth, were to take place at one period. The air would be fo crowded with noxious creatures, that neither man nor the larger animals could poffibly exift. Befides, the fpecies which feed upon particular plants, if they were produced at a time when thefe plants did not flourifh, would infallibly perifh for want of food. In Lapland, where the duration of heat is extremely fhort, the whole infects which inhabit that dreary and barren region are produced in a few weeks. Though the number of fpecies, compared with thofe of the more prolific climates, be very limited, the inconvenience is feverely felt. But every natural evil is accompanied with fome advantage. The rein-deer, upon which the exiftence of the Laplanders chiefly depends, are tormented by the fwarms of flies. To avoid their numberlefs enemies, thefe animals leave the vallies, and afcend the mountains, where the cold is too great for the flies to follow. In thefe lofty regions, the rein-deer feed during the hot feafon, and return to the vallies after the cold has deftroyed the myriads of infects. This forced migration has two good effects: It both preferves the health of the rein-deer, and the vegetables in the vallies, which otherwife would have been prematurely exhaufted.

The operation of engrafting was long thought to be peculiar to the vegetable kingdom. But M. Trembley found, that feveral fpecies of the frefh-water polypus could fuccefsfully undergo this wonderful procefs. Since his time, it has been difcovered, that the *actinia*, or fea-nettle, is likewife capable of being engrafted to an individual of the fame or of a different fpecies. In all thefe inftances, the portions of the divided animals grow together, and become diftinct individuals.

Having traced the general analogies between the ſtructure and oeconomy of the animal and vegetable, from the rudiments of their exiſtence till they have acquired full maturity, and performed the neceſſary office of multiplying their ſpecies, we proceed to the laſt and only melancholy branch of this ſubject, the unavoidable decay and death of every ſucceſſive individual in both kingdoms.

It is an invariable law of Nature, that all organized bodies ſhould have a conſtant tendency to diſſolution. But the periods of their exiſtence vary according to the ſpecies. Previous to actual reſolution, plants as well as animals are ſubject to a number of analogous affections and diſeaſes. When over-heated, plants ſhow evident marks of languor and fatigue: Their leaves become flaccid, their ſtems and branches bend toward the earth, their juices evaporate, and their whole texture aſſumes the appearances of weakneſs and decay. The application of too great a degree of cold makes the flowers, the leaves, the bark, and even the woody fibres, ſhrivel and contract in their dimenſions. When deprived of proper light and air, their colours fade, and they ſoon acquire a lurid and ſickly aſpect. They are likewiſe ſubject to be ſtarved for want of nouriſhment. The growth of plants, as well as that of animals, is checked by ſcanty ſupplies of food. When the ſoil or ſituation is unkindly, vegetables are always weak and dwarfiſh, and their prolific powers are diminiſhed. They may alſo be poiſoned by the abſorption of fluids hoſtile to their conſtitution. Beſide theſe general affections, common to the plant and animal, vegetables are injured, and often killed, by particular diſeaſes.

Some diſeaſes attack the leaves only, and produce ſpots of various colours, rugoſities, puſtules, galls, &c. Others are peculiar to the flowers and fruit, and often occaſion barrenneſs for a ſeaſon; and ſometimes this ſterility continues during the exiſtence of the plant. Others aſſault the viſcera, or internal organs, and give riſe to obſtructions, tumors, and a gradual reſolution and corruption of the whole fabrick. Many of the diſeaſes of plants are produced by the inſect tribes. Their wounds and depredations are not confined to particular parts, but extend from the root to the ſtem, branches, leaves, flowers, and fruit. Inſects not only injure the ſubſtance of plants, but, by feeding on their juices, deprive them of a part of their nouriſhment, and occaſion various diſeaſes or changes in their organization. Other diſeaſes of plants derive their origin from change of climate, from miaſmata or noxious vapours in the atmoſphere, and from improper culture. When wounded by external injuries, vegetables diſcharge their blood in copious ſtreams. If the wound be not mortal, the fibres on all ſides gradually ſhoot out, and cloſe the fracture by a callous ſubſtance.

From this general enumeration, it is obvious, that the diſeaſes of plants are not only ſimilar to thoſe of animals, but proceed from the ſame cauſes. In both kingdoms, ſome diſeaſes are only partial or ſuperficial, and are cured either by Nature, or by the aſſiſtance of art. Others are mortal, and ſucceeded by a total putrefaction or decompoſition of the individual.

But, though plants ſhould eſcape the numberleſs diſeaſes which daily threaten them, they have no defence againſt the ſlower approaches of old age, and its unavoidable conſequence, death. In progreſs of time, the veſſels gradually harden and loſe their tone. The juices no longer move with equal celerity as in youth. They are not abſorbed with the ſame preciſion. They at laſt ſtagnate and corrupt. This corruption is ſoon communicated to the veſſels in which the juices are contained, and produces a total ceſſation of all the vital functions.

The life of animals is diverſified by a number of ſucceſſive changes. Infancy, youth, manhood, old age, are characteriſed by imbecillity, beauty, fertility, dotage. All theſe viciſſitudes are conſpicuous in the vegetable world. Weak and tender in infancy, beautiful and vigorous in youth, robuſt and fruitful in manhood, and, when old age approaches, the head droops, the ſprings of life dry up, and the tottering vegetable, like the animal, returns to that duſt from which it ſprung.

Upon the whole, by taking a retroſpective view of the extreme difficulty of aſcertaining the boundaries which diſtinguiſh the animal from the vegetable, and of the ſimilarities in their ſtructure and organs, in their growth and nouriſhment, in their diſſemination and decay, it is apparent, that both theſe kingdoms conſtitute the ſame order of beings, and that Nature, in the formation of them, has operated upon one great and common model.

CHAPTER II.

Of the organs and general ſtructure of Animals—A ſhort view of the external and internal parts of the human body—This ſtructure compared with thoſe of Quadrupeds, Birds, Fiſhes, and Inſects—How far peculiarities of ſtructure are connected with peculiarities of manners and diſpoſitions.

IN Treating of this ſubject, it is not intended to dive into the depths of anatomical reſearch. On the contrary, I ſhall exhibit ſhort views only of the general ſtructure and organization of the various claſſes of animated beings, from man, who is the moſt perfect animal of which we have any knowledge, down to the inſect tribes. Conſidering man, therefore, as the ſtandard of animal perfection, we ſhall inſtitute frequent compariſons, and mark peculiar diſtinctions between him and the brute creation, both with regard to form, manners, and ſagacity. By following this plan, I hope I ſhall be enabled to render a ſubject which, at firſt ſight, may have a forbidding aſpect, both intereſting and agreeable.

STRUCTURE OF MAN.

The bones may be regarded as the baſis upon which the human body is conſtructed. The ſpine, or back-bone, conſiſts of a number of vertebrae, or ſmall bones, connected together by cartilages, articulations,

culations, and ligaments. In the centre of each vertebra there is a foramen, or hole, for the lodgement and continuation of the ſpinal marrow, which extends from the brain to the rump. From theſe vertebrae the arched bones called ribs proceed; and ſeven of them join the breaſt-bone on each ſide, where they terminate in cartilages, and form the cavity of the thorax, or cheſt. This cavity contains the heart and lungs; and the oeſophagus, or gullet, paſſes through it to reach the ſtomach. The five lower ribs, with a number of muſcles, form another cavity termed the *abdomen*, or belly, in which are contained the ſtomach, the bowels, the *omentum*, or cawl, the liver, the gall-bladder, the ſpleen, the pancreas, and the kidneys. The cheſt and abdomen are ſeparated from each other by the diaphragm, or midriff. The lower part of this laſt cavity contains the bladder of urine, and the rectum, or termination of the inteſtines. Beſide theſe, in females, the pelvis includes the uterus and its appendages. This part of the cavity is formed by the os ſacrum, or termination of the back-bone, and the two oſſa innominata.

The bones of the cranium and face are very numerous. They are connected together by means of ſutures, articulations, and membranes. The bones of the cranium include the brain, and its two membranous coverings, called the *pia* and *dura mater*, and the medulla oblongata, of which laſt the ſpinal marrow is a prolongation. The bones of the upper and under jaw form another cavity for the reception of the tongue and organs of ſpeech.

The only remaining bones are thoſe of the upper and lower extremities. The ſhoulder and collar bones articulate with the top of the arm and the breaſt-bone. The arm-bone, or *os humeri*, is joined to the two bones of the fore-arm, called *ulna* and *radius*, and theſe laſt to the bones of the *carpus*, or wriſt, by means of articulations

tions and firm membranes. To the bones of the wrist, those of the metacarpus and fingers are attached in a similar manner.

With regard to the lower extremities, the thigh-bone articulates above with the hip-bone, and below with the leg-bone and the rotula, or knee-pan. The leg, like the fore-arm, is composed of two bones, the tibia and fibula, which articulate with each other, and with the tarsal, or heel-bones of the foot; and to these last the metatarsal bones, and those of the toes, are joined.

From this outline, some idea may be formed of the human skeleton. The other parts of which our bodies are composed shall be mentioned in the same cursory manner.

The muscular part of the human fabric consists of numerous bundles of fleshy fibres. Each bundle, or distinct muscle, is inclosed in a cellular membrane, by which means they may be raised, or separated from one another by the hand of the anatomist. They are inserted, by strong tendinous extremities, into the different bones of which the skeleton is composed, and, by their contraction and distention, give rise to all the movements of the body. The muscles, therefore, may be considered as so many cords attached to the bones; and Nature has fixed them according to the most perfect principles of mechanism, so as to produce the fittest motions in the bones or parts for the movement of which they are intended.

The heart is a hollow muscular organ of a conical shape, and consists of four distinct cavities. The two largest are called *ventricles*, and the two smallest *auricles*. The heart is inclosed in the *pericardium*, a membranous bag, which likewise contains a quantity of water, or lymph. This water lubricates the heart, and facilitates all its motions. The heart is the general reservoir of the blood.

blood. By the contractions and dilatations of this mufcle, the blood is alternately thrown out of, and received into, its feveral cavities. When the heart contracts, the blood is propelled from the right ventricle into the lungs through the pulmonary arteries, which, like all the other arteries, are furnifhed with valves that play eafily forward, but admit not the blood to regurgitate toward the heart. The blood, after circulating through the lungs, returns into the left ventricle of the heart by the pulmonary vein. At the fame inftant, the left ventricle drives the blood into the aorta, a large artery which fends off branches to fupply the head and arms. Another large branch of the aorta defcends along the infide of the back-bone, and detaches numerous ramifications to nourifh the vifcera and inferior extremities. After ferving the moft remote extremities of the body, the arteries are converted into veins, which, in their return toward the heart, gradually unite into larger branches, till the whole terminate in one great trunk called the *vena cava*, which difcharges itfelf into the right ventricle of the heart, and completes the circulation.

Befide the heart, the thorax or cheft contains the lungs, or organs of refpiration. They are divided into five lobes, three of which lie on the right, and two on the left fide of the thorax. The fubftance of the lungs is chiefly compofed of infinite ramifications of the trachea or windpipe, which, after gradually becoming more and more minute, terminate in little cells or veficles, which have a free communication with one another. At each infpiration, thefe pipes and cells are filled with air, which is again difcharged by refpiration. In this manner, a circulation of air, which is neceffary to the exiftence of men and other animals, is conftantly kept up as long as life remains.

The

The inftruments and procefs of digeftion fall next to be confidered. The ftomach is a membranous and mufcular bag furnifhed with two orifices: By the one it has a communication with the *oefophagus*, or gullet, and by the other with the bowels, which begin at the ftomach and terminate at the anus. In the ftomach and inteftines there are immenfe numbers of minute veffels called *lacteals*, the mouths of which are conftantly open for the reception of the nutritious particles. After being moiftened and lubricated by the faliva, the food is received into the ftomach, where it is ftill farther diluted by the gaftric juice, which has the power of diffolving every kind of animal and vegetable fubftance. When the food has remained fome time in the ftomach, it is reduced to a grayifh pulp, mixed with fome chylous or milky particles. The thinner and more perfectly digefted parts of the food gradually pafs through the *pylorus*, or lower aperture of the ftomach, into the inteftines, where they are ftill farther attenuated and digefted by the bile and pancreatic juices. While the food is in this fluid ftate, it receives the denomination of *chyle*, and is continually abforbed by the mouths of the lacteal veins. Thefe veffels arife, like net-work, from the inner furface of the inteftines, pafs obliquely through their coats, and, running along the mefentery, unite, as they advance, into larger branches, and at laft terminate in the thoracic duct, or general receptacle of the chyle. Befide the lacteals, there is another fyftem of veffels called *lymphatic*, or abforbent veins: They are minute pellucid tubes, and generally lie clofe to the large blood-veffels. The lymphatics from all the lower parts of the body gradually unite as they approach the thoracic duct, into which they pour a colourlefs fluid by three or four large trunks; and the lymphatics from all the fuperior parts of the body likewife difcharge their lymph into the fame duct as it runs upward to terminate in the left fubclavian vein. By this curious and beautiful machinery, the chyle and lymph, which confift of the nutritious matters extracted from the food, enter the circulating ſyſtem, are converted into blood, and afford that conſtant ſupply of nouriſhment which the perpetual waſte of our bodies demands.

We ſhall next give a ſketch of thoſe important organs by which we are enabled to multiply and continue the ſpecies. The circulation of the blood, and the mode by which the quantity of it is continually kept up by freſh ſupplies of chyle, are effects which, in ſome meaſure, correſpond with our ideas of the machinery employed. The organs of generation exhibit a ſtill more complex ſpecimen of exquiſite mechaniſm. But the machinery employed, without the aid of experience, could never ſuggeſt the moſt diſtant idea of the effect to be produced.

In the male, the organs of generation conſiſt of the teſtes, the ſeminal veſſels, and the penis. The teſtes are two glandular bodies which poſſeſs the power of converting the blood into ſemen. They are originally formed and lodged in the abdomen; and it is not till after birth that they commonly paſs into the groin, and from thence fall into the ſcrotum, which is a muſcular bag prepared for their reception and defence. The teſtes of the hedgehog and of ſome other quadrupeds remain in the abdomen during life. Inſtances of the ſame kind ſometimes happen in the human ſpecies. Each teſticle is compoſed of the ſpermatic artery and vein. The blood paſſes very ſlowly through the ſpermatic artery, and produces an infinite number of convolutions in the ſubſtance of the teſticle, where it depoſits the ſemen, which is taken up by the ſemeniferous tubes. Theſe tubes at length unite, and, by an immenſe number of circumvolutions, form a kind of appendix to the teſticle, commonly known by the term *epidydymis*. The tubes of the epidydymis, after terminating in an excretory duct called *vas deferens*, aſcend toward the abdominal rings, and depoſit the ſemen in the ſeminal veſicles, which are two ſoft convoluted bodies ſituated between the rectum and bladder, and unite at their lower extremity: From theſe reſervoirs the ſemen is occaſionally diſcharged through the ſhort canals which open into the urethra. The penis is a cavernous and ſpungy ſubſtance perforated longitudinally by a canal called the *urethra*, which, by communicating with the bladder and ſeminal veſſels, anſwers the double purpoſe of diſcharging both the urine and ſemen.

With regard to the female organs, the uterus and its appendages merit a principal attention. The uterus is a hollow muſcular body ſituated between the rectum and bladder, and, when not in an impregnated ſtate, reſembles a pear, with the thickeſt end turned toward the abdomen. The entrance into the cavity of the uterus forms a ſmall protuberance, which has been compared to the mouth of a tench, and from this circumſtance it has received the name of *os tincae*. The uterus is connected to the ſides of the pelvis by two broad ligaments, which ſupport it in the vagina in a pendulous ſituation. From each ſide of the bottom of the uterus the two Fallopian tubes ariſe, paſs through the ſubſtance of the uterus, and extend along the broad ligaments till they reach the edge of the pelvis; from whence they are reflected backward, and turning over behind the ligaments, their extremities hang looſe in the pelvis. Theſe extremities, becauſe they have a ragged appearance, are called *fimbriae*, or *morſus diaboli*: Each Fallopian tube is about three inches long. Their cavities are at firſt very ſmall, but become gradually larger, like a trumpet, as they approach the fimbriae. Near the fimbriae of each tube, about an inch from the uterus, are ſituated the ovaria, or two oval bodies, about half the ſize of the male teſticle. They are covered with a production of the peritoneum, and hang looſe in the pelvis. In their ſubſtance there are ſeveral minute veſicles filled with lymph. The number of theſe veſicles ſeldom exceeds twelve in each ovarium. In mature females, theſe veſicles become exceedingly turgid; and a yellow coagulum gradually forms in one of them, which increaſes till its coat diſappears. It then changes into a hemiſpherical body called *corpus luteum*, which is deſcribed as being hollow and containing within its cavity very minute eggs, each of which, it is ſuppoſed, may be impregnated, and produce a foetus. After impregnation, one of theſe eggs, as we are informed by anatomiſts, is abſorbed by and paſſes through the Fa lopian tube into the uterus, where it is nouriſhed till mature for birth.

We ſhall conclude this ſubject with a conciſe account of the inſtruments of ſenſation. The organs hitherto deſcribed convey nothing more than the idea of an automaton, or ſelf-moving machine. But ſenſation, or the perception of pleaſure and pain, is effected by organs of a peculiar kind. Theſe organs are all comprehended under the general appellations of the *brain* and *nerves*.

Beſide the bones of the cranium, the brain is inveſted with two membranes, called *dura* and *pia mater*, becauſe they were ſuppoſed by the Arabians to be the ſource of all the other membranes of the body. Under the denomination of *brain* are comprehended three diſtinct parts, the *cerebrum*, the *cerebellum*, and *medulla oblongata*. The *cerebrum* is a ſoft medullary maſs, ſituated in the anterior part of the ſkull, and divided, by a portion of the dura mater, into two hemiſpheres. It conſiſts of two ſubſtances, the cortical, which is greyiſh, and the medullary, which is ſofter, and of a very white colour. The *cerebellum* is divided into two lobes, and its ſubſtance is firmer and more compact than that of the cerebrum. It is likewiſe compoſed of the cortical and medullary ſubſtances. The reunion of the medullary ſubſtances of the cerebrum and cerebellum, at the baſis of the ſkull, forms the *medulla oblongata*, of which the ſpinal marrow is a continuation. The brain of the human ſpecies is proportionally much larger than that of quadrupeds.

The brain and ſpinal marrow are ſuppoſed to be the origin of all the nerves or inſtruments of ſenſation. The nerves are, in general, cineritious, ſhining, inelaſtic cords. But they differ from each other in ſize, colour, and conſiſtence. From numberleſs experiments and obſervations, it is unqueſtionable, that the nerves are the inſtruments both of ſenſation and of animal motion. But, how theſe effects are produced by the nervous influence is a diſcovery ſtill to be made. The inquiry, however, has given riſe to ſeveral ingenious conjectures and hypotheſes. Some phyſiologiſts have maintained, that the nerves are ſolid cords, which may be divided into an infinite number of minute filaments; and that, by the vibrations of theſe cords, the various impreſſions and modifications of feeling are conveyed to the brain. Others, with more plauſibility, have ſuppoſed, that the nerves are aſſemblages of ſmall tubes; that a ſubtile fluid, ſometimes called *animal ſpirits*, is ſecreted in the brain and ſpinal marrow; and that by the influence or motions of this fluid all the ſenſations of animals are tranſmitted to the ſenſorium, or general repoſitory of ideas. But it is needleſs to dwell upon a ſubject covered with darkneſs, and which all the efforts of human powers will probably never bring to light.

Anatomiſts have deſcribed forty pair of nerves. Ten of them proceed from the medulla oblongata of the brain, and thirty from the ſpinal marrow. Theſe nerves, by ſending off innumerable ramifications, are diſtributed, like a net-work, over every part of the body, till they terminate, in the form of minute papillae, upon the ſkin. That the nerves are the immediate inſtruments of ſenſation, as well as of muſcular motion, has been proved by a thouſand uncontrovertible experiments. When the trunk of the ſciatic nerve is cut, the thigh and leg on that ſide inſtantly loſe all motion, and all ſenſe of pain, below the inciſion, and neither time nor art can ever reſtore the power of feeling or of moving. But the parts between

tween the incifion and the fpinal marrow, which is a continuation of the brain, retain their ufual degrees both of motion and of fenfation. From this experiment, it is evident, that the nerves are the organs by which fenfation and motion are effected, and that, for thefe important purpofes, an uninterrupted connection between any particular nerve and the brain, or fpinal marrow, is indifpenfible.

This fketch of the human fabric requires an apology to anatomical readers, who muft be fenfible of its many imperfections. To perfons who have not ftudied that curious and ufeful fcience, I imagined a general view of the ftructure of man, if properly compofed, might enable them to acquire more diftinct ideas of the many feeming deviations from the common plan obferved by Nature in the formation of the inferior and more imperfect animals.

OF THE STRUCTURE OF QUADRUPEDS.

Having delineated the ftructure and organs of the human fpecies, it is worthy of remark, that the intellect, or fagacity, of inferior animals augments or diminifhes in proportion as the formation of their bodies approaches to, or recedes from, that of man. Quadrupeds, accordingly, are more intelligent than birds; the fagacity of birds exceeds that of fifhes; and the dexterity and cunning of fifhes are fuperior to thofe of moft of the infect tribes. The fame gradation of mental powers is exhibited in different fpecies of the fame claffes of animals. The form of the orang outang makes the neareft approach to the human; and the arts he employs for his defence, the actions he performs, and the fagacity he difcovers, are fo aftonifhing, that fome philofophers have confidered him as a real human being in the moft debafed ftage of fociety. Next to the orang outang,

outang, the organs of the different ſpecies of apes and monkeys have the greateſt reſemblance to thoſe of man; and their powers of imitation, their addreſs in procuring their food, and in managing their young, their ingenuity, and their ſagacious manners, have contributed to the amuſement, and excited the admiration, of mankind in all ages and nations. The ſame relation between form and intellect may be traced in the dog, the cat, the ſow, the horſe, the ſheep, and the other ſpecies of quadrupeds.

With regard to the general ſtructure and figure of quadrupeds, a great variety is exhibited in the different kinds. But, when examined in detail, it is apparent, that they, as well as man, are all formed upon one primitive and general deſign. Beſide the organs of ſenſation, of circulation, of digeſtion, and of generation, without which moſt animals could neither ſubſiſt nor multiply, there is, even among thoſe parts that chiefly contribute to variety in external form, ſuch a wonderful reſemblance as neceſſarily conveys the idea of an original plan upon which the whole has been executed. For example, when the parts conſtituting a horſe are compared with the human frame, inſtead of being ſtruck with their difference, we are aſtoniſhed at their ſingular and almoſt perfect reſemblance. Take the ſkeleton of a man, ſays Buffon, incline the bones of the pelvis; ſhorten thoſe of the thighs, legs, and arms; join the phalanges of the fingers and toes; lengthen the jaws by ſhortening the frontal bones; and, laſtly, extend the ſpine of the back. This ſkeleton would no longer repreſent that of a man: It would be the ſkeleton of a horſe. For, by lengthening the back-bone and the jaws, the number of the vertebrae, ribs, and teeth, would be increaſed; and it is only by the number of theſe bones, and by the prolongation, contraction, and junction of others, that the ſkeleton of a horſe differs from that of a man. The ribs, which are eſſential to the figure of animals, are found equally in man, in quadrupeds, in birds, in fiſhes, and even in the turtle. The foot of the horſe, ſo apparently different from the hand of a man, is compoſed of ſimilar bones; and, at the extremity of each finger, we have the ſame ſmall bone, reſembling the ſhoe of a horſe, which bounds the foot of that animal. Raiſe the ſkeletons of quadrupeds, from the ape-kind to the mouſe, upon their hind-legs, and compare them with the ſkeleton of a man, the mind will be inſtantly ſtruck with the uniformity of ſtructure and deſign obſerved in the formation of the whole group. This uniformity is ſo conſtant, and the gradations from one ſpecies to another are ſo imperceptible, that to diſcover the marks of their diſcrimination requires the moſt minute attention. Even the bones of the tail will make but a ſlight impreſſion on the obſerver. The tail is only a prolongation of the *os coccygis*, or rump-bone, which is ſhort in man. The orang outang, and true apes, have no tail; and, in the baboons, and ſeveral other quadrupeds, the tail is exceedingly ſhort. Thus, in the creation of animals, the Supreme Being ſeems to have employed only one great idea, and, at the ſame time, to have diverſified it in every poſſible manner, that men might have an opportunity of admiring equally the magnificence of the execution and the ſimplicity of the deſign.

In quadrupeds, as well as in man, the bones are connected by articulations and membranes; and the different movements of theſe bones are performed by the operation of muſcles. The number, diſpoſition, and form of the muſcles, with a few exceptions ariſing from the figure and deſtination of parts peculiar to particular animals, are nearly the ſame in men and in quadrupeds. The circulation of their blood, the ſecretion of their fluids, and the proceſs of digeſtion, are carried on by organs perfectly ſimilar to thoſe of the human body. In the external covering, a ſmall difference takes place. Quadrupeds are furniſhed with a thick covering of hair, or wool, to defend them from the injuries of the weather. Being

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deftitute of art fufficient to make garments, Nature has fupplied that defect, by giving them a coat of hair, which varies in thicknefs according to the feafon of the year and the difference of climate. In Ruffia, Lapland, Kamtfchatka, and all the northern regions, the furs of animals are very thick and warm. But, in Turkey, Africa, and the fouthern parts of Afia and America, moft quadrupeds are thinly clad, and fome of them, as the Turkifh dog, are totally deftitute of hair.

The fkin of quadrupeds is difpofed nearly in the fame manner as the human, only it is more elaftic. Immediately under the fkin, there is a thin mufcular fubftance, called *panniculus carnofus*, which is common to all quadrupeds, except the hog and armadillo kinds. This fubftance, which is peculiar to quadrupeds, chiefly covers the trunk, and, by fuddenly fhaking and fhrivelling the fkin, enables thefe animals to drive off infects, or other offenfive bodies.

The fubftance of the nerves, or organs of fenfation, is the fame in the quadruped and in man. They originate from the brain and fpinal marrow, and are diftributed over all the internal and external parts of the body, in the fame manner as in the human frame.

Thus it appears, that, in general ftructure and organization, the brute creation is nearly allied to the human fpecies. Some differences, however, merit attention; becaufe a flight variation in ftructure, efpecially of the internal organs, is often accompanied with great diverfities in difpofitions, food, and manners.

Some animals feed upon flefh, others upon vegetables, and others upon a mixture of both. The difpofitions of fome fpecies are fierce; and their manners convey to us the ideas of cruelty and of barbarifm: The difpofitions and manners of other fpecies are foft and placid,

placid, and excite in us ideas of mildneſs, complacency, and innocence. The ferocity of the tyger and hyaena forms a perfect contraſt to the gentleneſs and inoffenſive behaviour of the ſheep and the ox. This oppoſition of manners has given riſe to the diſtinction of animals into rapacious and mild, carnivorous and herbivorous. In the ſtructure of theſe animals, whoſe characters are ſo oppoſite, ſome differences have been diſcovered, which indicate the intentions of Nature in forming them, and fully juſtify the ſeeming cruelty of their conduct.

In all the carnivorous tribes, the ſtomach is proportionally ſmaller, and the inteſtines ſhorter, than in thoſe animals which feed upon vegetables. As animals of the former kind live ſolely on fleſh, the ſhortneſs and narrowneſs of their inteſtines are accommodated to the nature of their food. Animal food is more eaſily reduced to chyle, and becomes ſooner putrid, than vegetable. Of courſe, if its juices were allowed to remain long in the inteſtines, inſtead of nouriſhing the body, they would produce the moſt fatal diſtempers. Beſide this accommodation of the inteſtines to the nature of their food, carnivorous animals are furniſhed with the neceſſary inſtruments for ſeizing and devouring their prey. Their heads are roundiſh, their jaws ſtrong, and their tuſks very long and ſharp. Some of them, as the lion, the tyger, and the whole cat-kind, are provided with long retractile claws. Thus both the internal and external ſtructure of this claſs of animals indicate their deſtination and manners. The rapid digeſtion of their food is a conſequence of the ſtrength and ſhortneſs of their inteſtines ; and the intolerable cravings of their appetite neceſſarily create a fierceneſs and rapacity of diſpoſition. Nothing leſs than blood can ſatiate them. Their cruelty, and the devaſtation they make among the weaker and more timid tribes, are effects reſulting ſolely from the ſtructure and organs with which Nature has thought proper to endow them. Hence, if there be any thing reprehenfible in the manners and difpofitions of carnivorous animals, Nature alone is to blame; for all their actions are determined by the irrefiftible impulfes of their organization. But, even in this feemingly cruel arrangement, Nature muft not be rafhly accufed. When we come to treat of the hoftilities of animals, I hope to be able to fhow, that Nature, in the formation of rapacious creatures, has acted with her ufual wifdom, and that beings of this kind have their ufes in the general fyftem and oeconomy of the univerfe.

As to the herbivorous tribes, or thofe animals which feed upon grain and herbage, a flight variation of organs produces the greateft effects upon their difpofition and manners. The inteftines of this tribe are very long, capacious, and convoluted. Vegetable food, efpecially herbage, contains a fmaller quantity of nutritive matter than the flefh of animals; neither is it fo eafily reduced to chyle. A larger quantity, therefore, as well as a longer detention in the ftomach and inteftines, is neceffary for the nourifhment of thefe creatures. Several quadrupeds comprehended under this order ruminate or chew the cud. Thefe are furnifhed with no lefs than four ftomachs. The food, after maftication, is thrown into the firft ftomach, where it remains fome time; after which, the animal forces it up again into the mouth, and gives it a fecond chewing. It is then fent directly into the fecond ftomach, and gradually paffes into the third and fourth; and, laftly, it is tranfmitted through the convolutions of the inteftines, and the dregs, or faeces, are thrown out of the body. By this machinery, herbivorous animals are enabled to devour large quantities of vegetable aliment, to retain it long in their bowels, and confequently to extract from it nutritive matter fufficient for their growth, fupport, and multiplication. Here the quantity compenfates the quality of the nutriment.

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It is true, that the horſe, the aſs, the hare, and ſome other animals which live upon herbage and grain, have only one ſtomach. But, though the horſe and aſs have one ſtomach only, their inteſtines are furniſhed with ſacs or pouches ſo large, that they may be compared to the paunch of ruminating animals; and hares, rabbits, the Guiney-pig, &c. have blind guts ſo long and capacious, that they are equivalent to a ſecond ſtomach. The hedgehog, the wild boar, the ſquirrel, &c. whoſe ſtomach and inteſtines are of a mean capacity, eat little herbage, but live chiefly upon ſeeds, fruits, and roots, which contain, in ſmall bounds, a greater quantity of nutritive matter than the leaves or ſtems of plants.

The external form of herbivorous animals, like that of the rapacious, is accommodated to their diſpoſitions and the oeconomy they are obliged to obſerve. That they might be enabled to reach the ſurface of the earth with eaſe, the legs of the larger kinds are proportionally ſhort; their head and neck long; and the muſcles and tendons of the neck are endowed with prodigious ſtrength. Without theſe peculiarities of ſtructure, they could not ſupport the prone poſture of the head in the tedious operation of browſing large quantities of herbage. The arrangement and form of their teeth likewiſe indicate the deſtination of the ruminating tribes. They have no cutting teeth in the upper jaw; and they are totally deprived of tuſks, or canine teeth. This laſt circumſtance, joined to their want of claws, ſhews that they are not intended to prey upon other animals. Horns are the only weapons of defence with which they are provided. From the nature of their food, therefore, and the internal and external configuration of their bodies, it is evident, that animals of this deſcription muſt be humble in their deportment and mild in their diſpoſition. This order of animals, accordingly, have uniformly been celebrated for gentleneſs of manners, ſubmiſſion, and timidity. Man has availed himſelf of thoſe diſpoſitions, by reducing almoſt the whole of this tribe to a domeſtic ſtate. But, in all this graciouſneſs of aſpect and tractability of temper, the animals themſelves have no merit. Their motions and actions are neceſſary reſults of the organs which Nature has beſtowed on them. It is obvious, therefore, that the diverſity of taſtes and diſpoſitions exhibited by different animals, ariſes not ſolely from any ſuperior agreeableneſs of particular kinds of food to their palates, or to a peculiar bias of their minds to benevolence and peace, but from a phyſical cauſe depending on the ſtructure of their bodies.

From what has been advanced, it follows, that man, whoſe ſtomach and inteſtines are proportionally of no great capacity, could not live upon herbage alone. It is an inconteſtible fact, however, that he can live tolerably well upon bread, herbs, and the fruits, roots, and ſeeds of plants; for we know whole nations, as well as particular orders of men, who are prohibited by their religion from eating any animal ſubſtance. But theſe examples are not ſufficient to convince us, that the health, vigour, and multiplication of mankind would be improved by feeding ſolely upon pot-herbs and bread. Beſides, his ſtomach and inteſtines are of a mean capacity between thoſe of the carnivorous and herbivorous animals. From this circumſtance alone we are warranted to conclude, that Nature intended him to feed partly on animal and partly on vegetable ſubſtances: And daily experience teaches us, that men fed in this manner are larger, ſtronger, and more prolific, than thoſe who are confined to a vegetable diet. If man had no other ſources of ſuperiority over the other animals than thoſe which originate from the ſtructure of his body, his diſpoſitions ought to be a medium between thoſe of the carnivorous and herbivorous tribes. When conſidered merely as an animal, this appears to be really the caſe. Vulgar and uninformed men, when pampered with a variety of animal food, are much more choleric, fierce, and cruel in their tempers than thoſe who live chiefly

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on vegetables. Animal food heats the blood, and makes it circulate with rapidity. In this ſituation, every object capable of exciting appetite or paſſion operates with redoubled force. The weak mind yields to the impulſe, and gives vent to every ſpecies of outrage which can debaſe human nature.

In the formation of his body, man has ſome advantages over particular animals. But theſe advantages are inconſiderable, and none of them, perhaps, are peculiar to the ſpecies. The ſtructure of all animals is nicely adjuſted to their deſtination, and the ſtation they occupy in the general ſcale of Being. The body of man is erect, and his attitude is ſaid to be that of command. His majeſtic deportment, and the firmneſs of his movements, announce the ſuperiority of his rank. His arms are not mere pillars for the ſupport of his body. His hands tread not the earth; neither do they loſe, by friction and preſſure, that exquiſite delicacy of feeling for which Nature had originally intended them. His arms and hands, on the contrary, are formed for purpoſes of a more noble kind. They are deſtined for executing the commands of his will, for laying hold of bodies, for removing obſtacles, for defending him from injuries, and for ſeizing and retaining objects of pleaſure. The features of this picture are exact delineations; but they are not the excluſive privilege of man. The orang outang walks erect, and he derives equal advantages from his hands and arms as the human ſpecies. Some apes have likewiſe the power of walking erect, with the additional faculty of employing their hands and arms as legs. They can walk, run, or leap, by the inſtrumentality either of two or of four extremities, as their ſituation or neceſſities may require. It is not, therefore, the fabric of man's body that entitles him to claim a ſuperiority over the other animals. The formation of their bodies is adjuſted with equal ſymmetry and perfection to the rank they hold in the general ſyſtem of animation. Many of them excel us in magnitude,

nitude, ſtrength, ſwiftneſs, and dexterity in particular movements. Their ſenſes are often more acute; they ſeize their prey, or procure herbage, fruits, and ſeeds of trees, with more facility than man, when limited to the powers of his animal nature. Hence the great ſource of man's ſuperiority over the brute creation muſt be derived from his mental faculties alone. Brutes enjoy the ſame inſtincts, the ſame appetites, and the ſame propenſities, as appear in the conſtitution of the human mind. But the inſtincts of brutes, though they are exerted with great certainty and preciſion, are much circumſcribed with regard to extenſion and improvement. Like man, they derive advantages from experience. But the concluſions they draw from this ſource are always feeble and extremely limited. Neither do they poſſeſs the ineſtimable faculty of tranſmitting the knowledge acquired by individuals from generation to generation. By means of their ſenſes, they learn to diſtinguiſh their enemies, or hurtful objects, at a diſtance; and they know how to avoid them. Experience teaches them to diſcriminate objects of pleaſure from thoſe of pain; and they act according to the feelings excited by theſe objects. Some animals can even accommodate their inſtincts to particular circumſtances and ſituations. The feelings of brutes are often more exquiſite than ours. They have ſenſations; but their faculty of comparing them, or of forming ideas, is much circumſcribed. A dog or a monkey can imitate ſome human actions, and are capable of receiving a certain degree of inſtruction. But their progreſs ſoon ſtops: Nature has fixed the boundaries of mental as well as of corporeal powers; and theſe boundaries are as various as the number of diſtinct ſpecies. Our wonder is equally excited by the ſagacity of ſome animals, and by the ſtupidity of others. This gradation of mental faculties originates from the number or paucity of inſtincts beſtowed on particular ſpecies, joined to the greater or ſmaller power of extending or modifying theſe inſtincts by experience and obſervation. Man is endowed with a greater number of inftincts than any other animal. The fuperiority of his rank, however, does not proceed from this fource alone. Man enjoys beyond every other animal the faculty of extending, improving, and modifying the different inftincts he has received from Nature. It is this faculty which enables him to compare his feelings, to form ideas, and to reafon concerning both. The bee makes cells, and the beaver conftructs habitations of clay. The order of their architecture, however, is invariably the fame. Man likewife builds houfes: But he is not forced, by an irrefiftible inftinct, to work always on the fame plan. His habitations, on the contrary, vary with the fancy of the individuals who defign and conftruct them.

Upon the whole, the dignity of man's rank depends not upon the ftructure of his organs. It is from the powers of his intellect alone that he is entitled to claim a fuperiority over the brute creation. Thefe powers enable him to form ideas, to abftract, to reafon, to invent, and to reach all the heights of fcience and of art.

The remarks formerly made are applicable to quadrupeds in general. But, before concluding this branch of the fubject, we fhall point out a few peculiarities in the ftructure of particular fpecies.

Befide the four ftomachs common to ruminating animals, the camel and dromedary have a fifth bag, which ferves them as a refervoir for holding water. This bag is capable of containing a very large quantity of that neceffary element. When the camel is thirfty, and has occafion to macerate his dry food in the operation of ruminating, by a fimple contraction of certain mufcles, he makes part of this water afcend into his ftomach, or even as high as the gullet. This fingular conftruction enables him to travel fix, eight, or even twelve days in the fandy defarts, without drinking, and to take at once a prodigious quantity of water, which remains in the

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reſervoir pure and limpid; becauſe neither the humours of the body, nor the juices that promote digeſtion, can have acceſs to it. Beſide this ſingularity of ſtructure, the camel has two large fleſhy bunches on his back, and the dromedary, or ſwift camel, one bunch; and the feet of both are covered with a very tough, but flexible ſubſtance. The conformation of theſe animals enables them to travel with heavy loads through the ſandy deſarts of the Eaſt, where the horſe or the aſs would inevitably periſh; becauſe Nature has not provided them with reſervoirs for holding and preſerving water, which are indiſpenſible in countries where none of that element can be procured but in particular places, that are often diſtant many days journey from each other. When we conſider the ſtructure of the camel and dromedary, we cannot be deceived with regard to their deſtination. The four ſtomachs indicate a vegetable diet, and the ſame docility and gentleneſs of manners which characteriſe the whole ruminating tribes. From the addition of a fifth bag, or reſervoir for the reception and preſervation of water, we ſhould expect to find ſome peculiarity of diſpoſition. In this conjecture we are not deceived. Of all animals which man has ſubjugated, the camel and dromedary are the moſt abject ſlaves. With incredible patience and ſubmiſſion they traverſe the burning ſands of Africa and Arabia, carrying burdens of amazing weight. Inſtead of diſcovering ſymptoms of reluctance, they ſpontaneouſly lie down on their knees till their maſter binds the unmerciful load. Arabia, and ſome parts of Africa, are the drieſt and moſt barren countries in the world. Both the conſtitution and ſtructure of camels are nicely adapted to the ſoil and climate in which they are produced. The Arabians conſider the camel as a gift ſent from heaven, a ſacred animal, without whoſe aſſiſtance they could neither ſubſiſt, traffick, nor travel. The milk of the camel is their common food. They alſo eat its fleſh; and of its hair they make garments. In poſſeſſion of their camels, the Arabs want nothing, and have nothing to fear. In one day they can perform a journey of fifty leagues into the desert, which cuts off every approach from their enemies. All the armies in the world would perish in pursuit of a troop of Arabs. An Arab, by the assistance of his camel, surmounts all the difficulties of a country which is neither covered with verdure, nor supplied with water. Notwithstanding the vigilance of his neighbours, and the superiority of their strength, he eludes their pursuit, and carries off, with impunity, all that he ravages from them. When about to undertake a depredatory expedition, an Arab makes his camels carry both his and their own provisions. When he reaches the confines of the desert, he robs the first passengers who come in his way, pillages the solitary houses, loads his camels with the booty, and, if pursued, he accelerates his retreat. On these occasions he displays his own talents as well as those of the camels. He mounts one of the fleetest, conducts the troop, and obliges them to travel day and night, without almost either stopping, eating, or drinking; and, in this manner, he often performs a journey of 300 leagues in eight days.

Another order of quadrupeds deserves our notice. Those which have been distinguished by the appellation of amphibious, are capable of remaining a long time under water. They live chiefly upon fishes, and, without this faculty of continuing a considerable time under water, they would be unable to procure their food. To this tribe belong the seal, the walrus, the manati, the sea-lion, &c. The seal and walrus are more nearly allied to land-quadrupeds than to the cetaceous animals; because they have four distinct legs, though nothing but the feet project beyond the skin. The toes of the feet are all connected by membranes, which enable these animals to swim in quest of their prey. They differ from terrestrial quadrupeds by the singular faculty of living with equal ease either in air or in water. This peculiarity of oeconomy and manners presupposes the necessity of some deviation from the general structure of quadru-

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peds; and Nature has accomplished this purpose by a very simple artifice.

In man, and in all land-quadrupeds, the lungs of the foetus have no motion, and receive no more blood than is requisite for their growth and nourishment. But, immediately after birth, the young animals respire, and the whole mass of blood circulates through their lungs. To carry on the circulation in the foetus state, another passage was necessary. The blood in the right auricle of the heart, instead of passing into the pulmonary artery, and, after circulating through the lungs, returning into the left auricle by the pulmonary vein, passes directly from the right to the left auricle through an aperture called the *foramen ovale*, which is situated in the partition of the heart that separates the cavities of the two auricles. By this contrivance, the mass of blood, without deviating into the lungs, enters the aorta, and is distributed over every part of the body. In man, and the other terrestrial animals, the foramen ovale of the heart, which permits the foetus to live without respiration, closes the moment after birth, and remains shut during life. Animals of this construction can neither live without air, nor remain long under water, without being suffocated.

But, in the seal, walrus, and other amphibious animals, the foramen ovale continues open during life, though the mothers bring forth on land, and respiration commences immediately after birth. By means of this perpetual aperture in the septum or partition of the heart, which allows a direct communication of the blood from the vena cava to the aorta, these animals enjoy the privilege of respiring, or not, at their pleasure.

This singularity in the structure of the heart, and the consequent capacity of living equally on land and in water, must necessarily produce

produce ſome peculiarities in the manners and diſpoſitions of amphibious animals. The ſeal, accordingly, whoſe hiſtory is beſt known, may be conſidered as holding the empire of the ſilent ocean. To this dignity he is entitled by his voice, his figure, and his intelligence, which render him ſo ſuperior to the fiſhes, that they ſeem to belong to another order of beings. Though his oeconomy be very different from that of our domeſtic animals, he is ſuſceptible of a ſpecies of education. He is reared by putting him frequently in water. He is taught to give a ſalute with his head and his voice. He approaches when called upon. His ſenſes are equally acute as thoſe of any quadruped; and, of courſe, his ſenſations and intellect are equally active. Both are exhibited in the gentleneſs of his manners, his ſocial diſpoſition, his affection for the female, his anxious attention to his offspring, and the expreſſive modulation of his voice. Beſides, he enjoys advantages which are peculiar to him. He is neither afraid of cold nor of heat. He lives indifferently on herbs, fleſh, or fiſh. He inhabits, without inconvenience, water, land, or ice. When aſſiſtance is neceſſary, the ſeals underſtand and mutually aſſiſt one another. The young diſtinguiſh their mother in the midſt of a numerous troop. They know her voice; and, when ſhe calls, they never fail to obey.

Before diſmiſſing this branch of the ſubject, the elephant muſt not be paſſed over in ſilence. His ſtructure is uncommon, and ſo are his talents. The elephant is the largeſt and moſt magnificent animal that at preſent treads the earth. Though he daily devours great quantities of herbage, leaves, and branches of trees, he has but one ſtomach, and does not ruminate. This want, however, is ſupplied by the magnitude and length of his inteſtines, and particularly of the colon, which is two or three feet in diameter by fifteen or twenty in length. In proportion to the ſize of the elephant, his eyes are very ſmall; but they are lively, brilliant, and capable of a pathetic expreffion of fentiment. He turns them flowly, and with mildnefs, toward his mafter. When he fpeaks, the animal regards him with an eye of friendfhip and attention. He feems to reflect with deliberation, and never determines till he has examined, without paffion or precipitation, the orders which he is defired to obey. The dog, whofe eyes are very expreffive, is too prompt and vivacious to allow us to diftinguifh with eafe the fucceffive fhades of his fenfations. But, as the elephant is naturally grave and moderate, we perceive in his eyes the order and fucceffion of his thoughts. His ears are very large, and much longer, even in proportion to his body, than thofe of the afs. They lie flat on the head, and are commonly pendulous; but he can raife and move them with fuch facility, that he ufes them as a fan to cool himfelf, and to defend his eyes from duft and infects. His ear is likewife remarkably fine; for he delights in the found of mufical inftruments, and moves in cadence to the trumpet and tabour.

But, in the ftructure of the elephant, the moft fingular organ is his trunk or probofcis. It is compofed of membranes, nerves, and mufcles; and it is at once an inftrument of feeling and of motion. The animal can not only move and bend the trunk, but he can contract, lengthen, and turn it on all fides. The extremity of the trunk terminates in a protuberance that ftretches out on the upper fide in the form of a finger; by means of which he lifts from the ground the fmalleft pieces of money; he felects herbs and flowers, and picks them up one by one; he unties the knots of ropes, opens and fhuts gates by turning the keys or pufhing back the bolts. In the middle of this protuberance or finger, there is a cavity in the form of a cup, and, in the bottom of the cup are the apertures of the two organs of fmelling and refpiration. This hand of the elephant poffeffes feveral advantages over that of the human. It is more flexible, and equally dexterous in laying hold of objects. Befides, ſides, he has his noſe in his hand, and is enabled to combine the power of his lungs with the action of his finger, and to attract fluids by a ſtrong ſuction, or to raiſe heavy bodies by applying to them the edge of his trunk, and making a vacuum within by a vigorous inſpiration. Hence delicacy of feeling, acuteneſs of ſmelling, facility of movement, and the power of ſuction, are united at the extremity of the elephant's trunk. Of all the inſtruments which Nature has beſtowed on her moſt favourite productions, the trunk of the elephant ſeems to be the moſt complete, as well as the moſt admirable. It is not only an organic inſtrument, but a triple ſenſe, whoſe united functions exhibit the effects of that wonderful ſagacity which exalts the elephant above all other quadrupeds. He is not ſo ſubject, as ſome other animals, to errors of viſion; becauſe he quickly rectifies them by the ſenſe of touch; and, by uſing his trunk as a long arm, for the purpoſe of touching remote objects, he acquires, like man, clear ideas of diſtances. But other animals, except ſuch as have a kind of arms and hands, can only acquire ideas of diſtances by traverſing ſpace with their bodies. Delicacy of feeling, the flexibility of the trunk, the power of ſuction, the ſenſe of ſmelling, and the length of the arm, convey ideas of the ſubſtance of bodies, of their external form, of their weight, of their ſalutary or noxious qualities, and of their diſtances. Thus, by the ſame organs, and by a ſimultaneous act, the elephant feels, perceives, and judges of ſeveral things at one time. It is by virtue of this combination of ſenſes and faculties in the trunk that the elephant is enabled to perform ſo many wonderful actions, notwithſtanding the enormity of his maſs and the diſproportions of his form. The thickneſs and rigidity of his body; the ſhortneſs and ſtiffneſs of his neck; the ſmallneſs of his head; the largeneſs of his ears, noſe, and tuſks; the minuteneſs of his eyes, mouth, genitals, and tail; his ſtraight, clumſy, and almoſt inflexible limbs; the ſhortneſs and ſmallneſs of his feet; the thickneſs and calloſity of his ſkin; all theſe deformities are the

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more obvious and disageeable, becaufe they are modelled on a large fcale, and moft of them are peculiar to the elephant.

From this fingular conformation, the animal is fubjected to many inconveniencies. He moves his head with difficulty, and cannot turn back without making a large circuit. For this reafon, the hunters attack him behind, or on the flanks, and avoid the effects of his rage by circular movements. He cannot feize any object on the ground with his mouth, becaufe his neck is too ftiff to allow his head to reach the earth. He is therefore obliged to lay hold of his food, and even of his drink, with his nofe, and then convey them to his mouth. It is likewife a confequence of this ftructure, that the young elephants are faid to fuck with their nofe, and afterwards pour the milk into their gullet.

OF THE STRUCTURE OF BIRDS.

From the figure and movements of the feathered tribes, we fhould be led to imagine that the ftructure of their organs was extremely different from that of quadrupeds. Their oeconomy and manner of living required fome variations in their frame. But thofe variations are by no means fo many or fo great as might be expected. Inftead of hairs, their bodies are covered with feathers, which, befide the beautiful variety of their colours, protect this clafs of animals from the affaults of rain and cold. They have only a couple of legs; but Nature has furnifhed them with two additional inftruments of motion, by which they are enabled to rife from the furface of the earth, and to fly with amazing rapidity through the air. The wings are articulated with the breaft-bone, and their motions are performed by mufcles of remarkable ftrength. Many birds are continually paffing through

through hedges and thickets. To defend their eyes, therefore, from external injuries, as well as from too much light when flying in opposition to the rays of the ſun, they are furniſhed with a membrane called *membrana nictitans*, which, like a curtain, can at pleaſure be drawn over the whole eye. This covering is neither opaque nor pellucid; but, being ſomewhat tranſparent, it allows as many rays to enter as render any object juſt viſible, and enable them to direct their progreſs through the air. It is by the inſtrumentality of this membrane that the eagle looks at the ſun. The feathers of all birds are inſerted into the ſkin in ſuch a manner that they naturally lie backward from the head; and allow the rain to run off their bodies, and, by turning their heads in oppoſition to the wind, prevent the wind from rumpling their feathers and retarding their flight. Beſide this proviſion, the rump of birds terminates in a large gland, which ſecretes an oily ſubſtance. When the feathers are too dry, or any way diſordered, the animals ſqueeze this gland with their bills, extract the oil, and with it they beſmear and dreſs the feathers. By this means the admiſſion of water is totally prevented. Birds have no ſeparate ribs; but the breaſt-bone, which is very large, joins the back-bone, and ſupplies their place.

With regard to the external figure of birds, the form of their bodies is nicely adapted to their manners and the mode of life they are deſtined to purſue. By ſtriking the air with their wings, they move forward in that element, and their tail ſerves them as a rudder to direct their courſe. Their breaſt-bone, inſtead of being flat, riſes gradually from the ſpine and terminates in a ſharp ridge or keel, which enables them to cut the air with greater facility. For the ſame purpoſe, the heads of birds are proportionally ſmaller than thoſe of quadrupeds, and moſt of them terminate in light ſharp-pointed beaks. They are likewiſe deprived of external ears, and of protuberant noſtrils. Their tails, inſtead of vertebrae, muſcles, and ſkin, conſiſt entirely of feathers. They have no pendulous ſcrotum, no bladder, no fleſhy uterus. Neither have they an epiglottis, though many of them poſſeſs great powers of modulation, and ſome of them may even be taught to articulate words. To lighten their beaks, they are deprived of lips and teeth; and their abdomen or belly is proportionally ſmall and narrow.

From this general view of the external figure and ſtructure of birds, it is apparent, that Nature has deſigned them for two diſtinct kinds of motion. They can, at pleaſure, either walk on the ſurface of the earth, or mount aloft, and penetrate the airy regions with prodigious ſwiftneſs.

Some peculiarities in the internal ſtructure of birds deſerve our notice.

Like quadrupeds, the feathered tribes are divided into granivorous and carnivorous; and their manners and diſpoſitions correſpond with their internal and external conformation.

In the granivorous claſs, the oeſophagus or gullet runs down the neck, and terminates in a pretty large membranous ſac, called the *ingluvies*, or craw, where the food is macerated, and partly diſſolved by a liquor ſecreted from glands ſpread over the ſurface of this ſac. Some birds, as the rooks and the pigeon kind, have the power of bringing up the food from this ſac into their mouths, and feeding their young with it in a half digeſted form. After macerating for ſome time, the food paſſes through the remainder of the gullet into another ſpecies of ſtomach denominated *ventriculus ſuccenturiatus*, which is a continuation of the gullet. Here the food receives a farther dilution. From this ſecond ſtomach, the food is tranſmitted to the gizzard, or true ſtomach, which conſiſts of two very ſtrong

 muſcles,

muſcles, covered externally with a tendinous ſubſtance, and lined with a thick, firm membrane. The remarkable ſtrength of the gizzard was formerly ſuppoſed to aſſiſt the digeſtion of granivorous birds by attrition. But this notion has of late been entirely exploded; for Doctor Stevens, and, after him, Spalanzani, have demonſtrated, by unequivocal experiments, that digeſtion is performed ſolely by the diſſolving powers of the gaſtric juices *. The other inteſtines are proportionally larger, and much longer than thoſe of the carnivorous birds.

The ſtructure of the heart, in granivorous birds, is nearly the ſame with that of quadrupeds.

The lungs hang not looſe in the cavity of the thorax, but are fixed to the back-bone: Neither are they divided into lobes, as in man and other animals whoſe ſpines admit of conſiderable motion. They are red, ſpongy bodies, covered with a membrane that is pervious, and communicates with the large veſicles or air-bags which are ſpread over the whole abdomen. Theſe veſicles, when diſtended with air, render the bodies of birds ſpecifically light. They likewiſe ſupply the place of a diaphragm, and ſtrong abdominal muſcles. They produce the ſame effects on the viſcera as theſe muſcles would have done, without the inconveniency of giving an additional weight to the body.

Birds have no bladder of urine: But a blueiſh-coloured canal, or ureter, is ſent off from each kidney, and terminates in the rectum. Their urine is diſcharged along with the faeces. It is a whitiſh ſubſtance, and turns chalky when expoſed to the air.

* See Stevens Diſſert. Med. Inaug. De Alimentorum Concoctione, Edin. 1777, and Spalanzani.

The teſticles of the male are ſituated on each ſide of the back-bone, and are very large in proportion to the ſize of the animal. From the teſticles proceed two ſeminal ducts, which at firſt are ſtraight, but afterwards acquire a convoluted form, as in the epidydymus of man. Theſe ducts terminate in the penis, of which the cock has two, one on each ſide of the common cloaca. They are very ſmall and ſhort; and, from this circumſtance, they long eſcaped the notice of anatomiſts.

In the female, the cluſter of yolks, being analogous to the human ovaria, are attached to the back-bone by a membrane. This membrane is very thin, and continues down to the uterus. The yolk, after ſeparating from its ſtalk, paſſes into a canal called the *infundibulum*, where it receives a gelatinous liquor, which, with what it farther acquires in the uterus, compoſes the white of the egg. The uterus is a large bag, ſituated at the end of the infundibulum, and is full of wrinkles on the inſide. Here the egg receives it laſt covering, or ſhell, and is puſhed out of the vagina at an aperture placed immediately above the anus.

From this deſcription of the ſtructure of granivorous birds, the analogy between them and the herbivorous quadrupeds is conſpicuous. In both, the number of their ſtomachs, the length and capacity of their inteſtines, and the quality of their food, are very ſimilar. But this analogy is not confined to ſtructure and organs: It extends to manners and diſpoſitions. Like the herbivorous quadrupeds, this order of birds are diſtinguiſhed by the gentleneſs and complacency of their tempers. Contented with the ſeeds of plants, or ſmall inſects, the ſtronger never wage war with the weaker. Their chief attention is occupied in procuring food, in hatching and rearing their young; and their vigilance is kept perpetually active in eluding the ſnares of men and other rapacious animals. The whole are a timid race, and many of them are ſo tractable that they may eaſily be rendered domeſtic. Man, accordingly, ever attentive to his intereſt, has not failed to derive advantage from the innocence and ſtupidity of theſe animals. Of the gallinaceous and duck kind, which are the moſt prolific, and conſequently the moſt profitable, he has chiefly ſelected the hen, the gooſe, the duck, the turkey, and the peacock. In this ſelection he has diſcovered his ſagacity; for, inſtead of pairing, theſe birds are polygamous, one male being ſufficient to fertilize a number of females, which is a great ſaving in the article of food.

With regard to carnivorous birds, their general conformation is nearly the ſame with thoſe of the granivorous kind. They have the ſame number of ſtomachs; but all of them are ſmaller and weaker. Their inteſtines are alſo much ſhorter. To enable them to procure food, they are obliged to fly quickly, and continue long on the wing. Their wings, accordingly, are proportionally longer, and they have more ſtrength in their muſcles. For the purpoſe of ſeizing and devouring prey, Nature has beſtowed on them ſtrong hooked bills, and long ſharp claws or pounces. They have alſo large heads, ſhort necks, ſtrong brawny thighs, and ſharp-ſighted eyes.

Like rapacious quadrupeds, birds of prey are capable of enduring hunger for a great length of time. This faculty is, perhaps, acquired partly by habit; becauſe the obtaining of their food is often very precarious. The females are larger, ſtronger, and more beautiful both in ſhape and plumage, than the males. For this reaſon, the male hawks are called *tercels, or thirds*, becauſe they are ſuppoſed to be one third leſs than the females. Nature ſeems to have beſtowed this ſuperiority of ſize and ſtrength upon the female, becauſe ſhe is obliged to procure food both for herſelf and for her progeny.

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The analogy between the ſtructure of rapacious birds and carnivorous quadrupeds is obvious. Both of them are provided with weapons which indicate deſtruction and rapine. Their manners, are alſo fierce and unſocial. They never, if the vulture be excepted, herd together in flocks, like the inoffenſive granivorous tribes. When not on the wing, they conceal themſelves on the tops of ſequeſtered rocks, or in the depths of the foreſts, where they ſpend their time in ſullen ſolitude. Thoſe of them which feed upon carion, as the raven, have the ſenſe of ſmelling ſo acute, that they ſcent dead carcaſſes at amazing diſtances.

Beſide theſe great diviſions of birds into granivorous and rapacious, whoſe manners and diſpoſitions perfectly coincide with the ſtructure of their bodies, there are other tribes to whom Nature has given peculiar organs. In all theſe deviations from the common ſtructure, a ſingularity in the mode of living, and the oeconomy of the animal, is the invariable reſult.

Like the amphibious animals, a number of fowls live chiefly in the water, and feed upon fiſhes and aquatic inſects. To enable them to ſwim and to dive in queſt of food, their toes are connected together by broad membranes or webs. By ſtretching their toes, and ſtriking the water backward with theſe webs, their bodies are moved forward, and they employ their tail as a rudder to direct their courſe. Without theſe additional inſtruments, fowls could not ſwim; and, accordingly, ſuch birds as are not provided with webs never take to the water. But thoſe furniſhed with webs have ſuch a ſtrong propenſity to water, that, when reſtrained from their favourite element, they diſcover the greateſt uneaſineſs, and, when their liberty is reſtored, they fly in a direct courſe either to the ſea, a river, or a lake.

There

There is another tribe of aquatic birds, ſome of which feed upon fiſhes and inſects, and others live principally by ſucking certain juices from mud. Both theſe kinds frequent marſhy places, or the margins of lakes and rivers. They do not ſwim, but wade, in queſt of food. This ſingularity in their manners required a correſpondent variation in their form and ſtructure. To enable them to wade in waters and in mires, Nature has provided them with longs legs, naked of feathers for a conſiderable ſpace above the knees. Their toes are not, like thoſe of the ſwimmers, connected by continued membranous webs. Moſt of them have likewiſe very ong necks and bills, to enable them to ſearch for and apprehend their food. To theſe tribes belong the crane, the herons, the bittern or mire-drum, the ſtork, the ſpoon-bill, the woodcock, the ſnipe, and many other ſpecies.

Having given a general idea of the ſtructure and oeconomy of birds, we ſhall next make a few remarks on the form and manners of fiſhes.

OF THE STRUCTURE AND ORGANS OF FISHES.

It is one great and benevolent intention of Nature, that no part of the univerſe ſhould be deprived of inhabitants. The earth, the air, the waters, are full of living beings, who are not only conſcious of their exiſtence, but enjoy degrees of happineſs proportioned to their natures, and the purpoſes they are deſtined to anſwer in the general ſcale of animation. The different elements in which they live neceſſarily required a variety in their form, their food, and their manners. The inhabitants of the earth and air have already been partially deſcribed: Thoſe of the waters are next to be conſidered.

The

The bodies of moſt fiſhes are covered with a ſtrong, thick, ſkin, in which numberleſs ſcales are inſerted in an imbricated form, or like tiles on the roofs of houſes. Many of them, and particularly thoſe which are ſhaped like the cod, the trout, and the haddock, have a longitudinal line on each ſide. In theſe lines there are a number of ſmall ducts or apertures, which throw out a mucous ſubſtance that lubricates their ſkins, and ſeems to anſwer the ſame purpoſes as the mucous glands or ducts placed in moſt of our internal organs.

Fiſhes are deſtitute of hands and feet. Their progreſſive motion, therefore, is performed in a manner different from that of quadrupeds and birds. Their inſtruments of motion are fins, or machines conſiſting of a number of elaſtic beams, connected to one another by firm membranes. Their tails are of the ſame texture. Their ſpine is remarkably flexible toward the poſterior part of the body, and here the ſtrongeſt muſcles are likewiſe inſerted. They have a power of contracting and dilating their tails at pleaſure; by which means, and by the aſſiſtance of the fins, they move forward in the ſame manner as a boat with oars on its ſides and a rudder at its ſtern. Fiſhes have no neck: As they ſeek their food in a horizontal poſition, and can move their bodies either upward or downward, a long neck would neceſſarily have impeded their motion through the water.

The form of fiſhes is extremely various; and, if their hiſtory were ſufficiently known, the connection between their ſtructure and their manners would be equally apparent as in the other tribes with which we are better acquainted. Some fiſhes are long and cylindrical, as the ſea-ſerpent, and all the eel-ſhaped ſpecies. The eel-kind, from their figure, are enabled to trail their bodies along the bottom, and to conceal themſelves below the ſand or mud. Others are leſs cylindrical, and proportionally ſhorter, as the mackrel, the

3 cod,

cod, the herring, the ſalmon, &c. Theſe, from the number and poſition of their fins, as well as from the ſhape of their bodies, are deſtined for quicker motion, and for travelling to great diſtances in queſt of food, or for ſpawning in ſhoals or in rivers. Others, as the flounder, the ſkate, the turbet, torpedo, &c. are broad and compreſſed. Theſe, like the eel-kind, frequent muddy bottoms. Others are triangular, quadrangular, round, &c. Beſide thoſe which approach to regular figures, the variations and compoſitions are ſo numerous, that the forms of fiſhes are much more diverſified than thoſe of quadrupeds or birds. To defend themſelves againſt their enemies, many fiſhes are armed with ſtrong, ſharp ſpines or prickles. For the ſame purpoſe, and likewiſe for wounding or killing their prey, ſome have a large horn on their front, and others a ſword, or rather a ſaw, which are tremendous weapons. The more timid and defenceleſs tribes are endowed with the faculty of rapid motion; and ſome of them have fins ſo large and flexible, that, when hard purſued, they are enabled to leave their natural element, to dart through the air to conſiderable diſtances, and diſappoint the deſigns of their enemies.

Fiſhes are as much diverſified in ſize as in figure. The ocean produces the largeſt animals which now inhabit this globe. The enormous maſſes of the whale and walrus tribes far exceed thoſe of the elephant, rhinoceros, or river-horſe, the largeſt terreſtrial animals of which we have any proper knowledge. From the immenſe bones, however, found in Siberia and many parts of Europe, we are induced to believe, that land animals have formerly exiſted whoſe ſize muſt have been much larger than that of the preſent elephant. This animal, whoſe ſpecies is now ſuppoſed to be extinguiſhed, is known among naturaliſts by the denomination of the *mammouth*. Near the river Ohio, ſome prodigious bones and teeth have lately been diſcovered, which indicate an animal of incredible magnitude.

With

With regard to internal ſtructure, fiſhes, like land-animals, are furniſhed with a back-bone and ribs, which run from the head to the tail. To theſe, the bones of the head, and the fins, all the muſcles and inſtruments of motion, are attached.

The mouths of moſt fiſhes are furniſhed with teeth; but in ſome, as the mullet, ſturgeon, &c. the teeth are wanting. In ſome, the teeth are ſituated on the jaw-bones, in others, on the tongue and palate. The teeth of fiſhes are principally deſigned for laying hold of and detaining their prey, which they generally ſwallow entire. For this purpoſe, the teeth are commonly ſerrated, or bent inward, like tenter-hooks. By this ſtructure, ſmall fiſhes are eaſily forced downwards, and their return is at the ſame time prevented.

In fiſhes, the organ of ſmelling is large; and they have a power of contracting and dilating, at pleaſure, the entry into their noſe.

It was formerly doubted whether fiſhes were endowed with the ſenſe of hearing. But that doubt is now fully removed; becauſe it has been found, that, like other animals, they have a complete organ of hearing, and that water is a proper medium for the conveyance of ſound. Beſides, in the ſkate, and ſome other genera, the learned and ingenious Dr Monro, Profeſſor of Anatomy in the College of Edinburgh, has lately diſcovered an aperture which leads directly to the internal parts of the ear.

The gullet of fiſhes is ſo ſhort that it is hardly to be diſtinguiſhed from the ſtomach, which is of an oblong figure. The guts are very ſhort, making only three convolutions, the laſt of which terminates in the common vent for the faeces, urine, and ſemen. From this ſtructure of the ſtomach and inteſtines, analogy would lead us to conclude, that fiſhes live chiefly upon animal food. Experience, accordingly,

cordingly, teaches us, that almoſt all fiſhes prey upon the ſmaller kinds, and even devour their own young. The liver is proportionally large, of a whitiſh colour, and ſituated on the left ſide. The gall-bladder lies at a conſiderable diſtance from the liver, and diſcharges the gall into the gut. In fiſhes, the organs of generation are two bags ſituated in the abdomen, and uniting near the anus. In the male, theſe bags are filled with a thick whitiſh ſubſtance called the *milt*, and in the female with an infinite number of minute eggs called the *roe*. At the ſeaſon of ſpawning, the bags of both male and female are greatly diſtended; but, at other times, the male organs can ſcarcely be diſtinguiſhed from thoſe of the female.

The ſwimming bladder is an oblong, white, membranous bag, which contains nothing but a quantity of elaſtic air. It lies cloſe to the back-bone, and has a pretty ſtrong muſcular coat. By contracting this coat, and, of courſe, condenſing the air it contains, ſome fiſhes are enabled to render their bodies ſpecifically heavier than water, and to ſink to the bottom; and, when the muſcular fibres ceaſe to act, the air dilates, and makes their bodies ſpecifically lighter. By this curious piece of mechaniſm, the animals have the power of ſinking to the bottom, or of riſing to the ſurface. According to the different degrees of contraction and dilatation of this bladder, fiſhes can, at pleaſure, keep themſelves higher or lower in the water. Hence flounders, ſoles, ſkate, and other fiſhes which have no ſwimming bladder, always grovel at or near the bottom. It is likewiſe a conſequence of the relaxation of this bladder, that dead fiſhes which are furniſhed with it uniformly riſe to the ſurface. The air-bag, in ſome fiſhes, communicates, by a duct, with the gullet, and, in others, with the ſtomach. At the upper end of the air-bag, there are red-coloured glandular bodies connected with the kidneys. From the kidneys the ureters proceed downward to their inſertion in the urinary bladder, which lies in the lower part of the abdomen, and the urethra terminates in the anus.

Fiſhes have a membranous diaphragm, or midriff, that forms a ſack in which the heart is contained. The heart is of a triangular figure. It has only one auricle, one ventricle, and one great artery. This artery, inſtead of ſupplying all the parts of the body, as in the frog, is diſtributed entirely on the gills. All the branches terminate there, and become at laſt ſo ſmall that they eſcape the naked eye. The branchiae, or gills, lie in two large ſlits on each ſide of the head, and are analogous to the lungs of land-animals. The figure of the gills is ſemicircular, and on each ſide of them are immenſe numbers of fibrils reſembling fringes. The gills are perpetually ſubjected to an alternate motion from the preſſure of the water and the action of the muſcles. They are covered with a large flap, which allows an exit to the water neceſſarily taken in by the animals every time their mouths are opened. The blood is again collected by a vaſt number of ſmall veins, which, inſtead of going back a ſecond time to the heart, immediately unite, and form an aorta deſcendens, which ſends off branches to ſupply all the parts of the body, except the gills. From the extremities of theſe branches the blood is collected by veins, and returned to the heart nearly in the ſame manner as in other animals.

The organs by which the nutritious part of the food of fiſhes are extracted and conveyed to the general maſs of blood, and known by the names of lacteal, abſorbent, and lymphatic veſſels, are ſo analogous to thoſe of men and quadrupeds, that it is unneceſſary to deſcribe them. For the ſame reaſon, no deſcription ſhall be given of the nerves, which, as in other animals, proceed from the brain and ſpinal marrow, and are diſtributed over every part of the body.

Having

Having finiſhed this ſketch of the ſtructure and organs of fiſhes, it is almoſt needleſs to remark, that, though they live in a different element, and vary greatly from land-animals in figure, Nature, in the formation of their bodies, in the mode of their nutrition, reſpiration, and ſenſation, has acted upon the ſame great and general plan.

We are now to take a view of the ſtructure of inſects, a numerous claſs of animals, moſt of whom recede farther from the common mode of animal organization than any of the other claſſes.

OF THE STRUCTURE OF INSECTS.

In the firſt chapter, a few obſervations were made concerning the ſtructure and organs of inſects, in order to ſhow more clearly the analogies between animals and vegetables. Theſe it is unneceſſary to repeat. We ſhall therefore proceed to a more particular examination of the ſtructure of inſects, and to trace the connection between that and their manners.

Inſects exhibit ſuch an immenſe variety in figure, colour, and diſpoſition of parts, that Naturaliſts have found it neceſſary to arrange them into different tribes or families. Theſe tribes are diſtinguiſhed from one another by certain peculiarities in the ſtructure of their bodies.

The moſt general diviſion of inſects is derived from the circumſtance of their having or wanting wings, and from the number and ſubſtances of which theſe inſtruments of motion are compoſed. They are diſtinguiſhed from all other animals by many peculiarities of form. None of the other claffes have more legs than four. But moft infects have fix; and many of them have eight, ten, fourteen, fixteen, eighteen, and even a hundred, legs. Befide the number of legs, infects are furnifhed with antennae or feelers. Thefe feelers, by which infects grope and examine the fubftances they meet with, are compofed of a great number of articulations or joints. Linnaeus, and other Naturalifts, maintain, that the ufes of thefe feelers are totally unknown. But the flighteft attention to the manner in which fome infects employ their feelers will fatisfy us of at leaft one ufe they derive from thefe organs. When a winglefs infect is placed at the end of a twig, or in any fituation where it meets with a vacuity, it moves the feelers backward and forward, elevates, depreffes, and bends them from fide to fide, and will not advance farther, left it fhould fall. Place a ftick, or any other fubftance, within reach of the feelers; the animal immediately applies them to this new object, examines whether it is fufficient to fupport the weight of its body, and inftantly proceeds in its journey. Though moft infects are provided with eyes, yet the lenfes of which they confift are fo fmall and convex, that they can fee diftinctly but at fmall diftances, and, of courfe, muft be very incompetent judges of the vicinity or remotenefs of objects. To remedy this defect, infects are provided with feelers, which are perpetually in motion while the animals walk. By the fame inftruments, they are enabled to walk with fafety in the dark.

No other animals but the infect tribes have more than two eyes. Some of them have four, as the phalangium; others, as the fpider and fcorpion, have eight eyes. In a few infects, the eyes are fmooth; in all the others, they are hemifpherical, and confift of many thoufand diftinct lenfes. The eyes are abfolutely immoveable: But this defect is fupplied by the vaft number of lenfes, which, from the diverfity of their pofitions, are capable of viewing objects in every direction.

rection. By the fmallnefs and convexity of thefe lenfes, which produce the fame effect as the object glafs of a microfcope, infects are enabled to fee bodies that are too minute to be perceived by the human eye.

Another peculiarity deferves our notice. No animal, except a numerous tribe of four-winged infects, have more than two wings.

With regard to fex, quadrupeds, birds, and fifhes, are diftinguifhed into males and females. But the bee and the ant furnifh examples of neuters, which are abfolutely barren: And the earthworm, and feveral fhell infects, are hermaphrodite, each individual poffeffing the prolific powers of both male and female.

It is likewife remarkable, that all winged infects undergo three metamorphofes or changes of form: The egg is difcharged from the body of the female in the fame manner as in other oviparous animals. By a wonderful inftinct, thefe feemingly ftupid creatures uniformly depofit their eggs on fuch animal or vegetable fubftances as furnifh proper food for the worm or caterpillar, that is to be hatched by the heat of the fun. The worm or caterpillar is the firft ftate. The bodies of caterpillars are foft and moift. They have no wings, and are totally deprived of the faculty of generation. After continuing for fome time in this reptile ftate, they are transformed into a chryfalis, which is drier and harder than the caterpillar. The chryfales of fome infects are naked, and thofe of others are covered with a filken web, fpun by the animals before their change is completed. In this ftate, many of them lie motionlefs, and feemingly inanimate, during the whole winter. When the fpring or fummer heats return, they burft from their laft prifon, and, from vile reptiles, are transformed into beautiful flies. In this perfect ftate they are exceedingly active, fly about in queft of their mates, and, after

propagating

propagating their ſpecies, the females depoſit their eggs, and the ſame circle of animation and change perpetually goes round. Hence the ſtructure and figure of the ſame individual animals are threefold, which renders the knowledge of inſects extremely complicated, as we muſt be acquainted with them in the ſeveral forms they ſucceſſively aſſume.

There is another peculiarity in the ſtructure of inſects. They are deprived of bones. But that defect is ſupplied, in ſome, by a membranous or muſcular ſkin, and, in others, by a cruſtaceous or horny covering. In this circumſtance, inſects reſemble the ſhell-animals, whoſe bones conſtitute the external parts of their bodies.

In general, the bodies of inſects are compoſed of a head, trunk, and abdomen. The head is commonly attached to the trunk by a joint or articulation. Beſide eyes, feelers, and mouth, the heads of ſome inſects are furniſhed with *palpi* fixed to the mouth; and they are either four or ſix in number. Each of them conſiſts of two, three, or four joints, and are often miſtaken for the antennae or feelers. Theſe inſtruments ſeem to ſerve the animals inſtead of hands; for they employ the palpi to bring the food to their mouths, and to keep it ſteady while eating. It is aſſerted by Linnaeus, and other Naturaliſts, that the heads of inſects are deſtitute of brains, noſtrils, and ears. The minuteneſs of the animals under conſideration may have hitherto prevented us from diſtinguiſhing theſe organs. If they want a brain, it is certain that their ſenſe of ſeeing is acute; and we know that they are amply ſupplied with nerves, which produce the ſame effects as the brain in larger animals. If they are deprived of noſtrils, the ſlighteſt attention muſt convince us, that ſome of them poſſeſs the ſenſe of ſmelling in a very high degree. Upon any other ſuppoſition, how ſhould the different ſpecies of flies, the moment they eſcape from the chryſalis ſtate, diſtinguifh, and directly approach, the different animal and vegetable fubftances Nature has deftined for their refpective nourifhment? A piece of meat is no fooner expofed to the air than it is covered with flefh flies, upon which they both feed and depofit their eggs. Without this fenfe, how fhould wafps, and other flies, be allured from confiderable diftances into bottles encrufted with honey or molaffes? Thefe, and fimilar actions, cannot be effects of fight; for the diftance, the minutenefs, and frequently the pofition of the food, render it impoffible for the eye to difcover thofe fubftances to which they inftantly refort.

With regard to hearing, it is more difficult to determine whether infects be endowed with this fenfe. We can judge of it, not by the knife of the Anatomift, but by the affections and motions of the animals themfelves. Several trials I have made on houfe-flies incline me to think that thefe animals poffefs a fenfe of a nature fimilar, at leaft, to that of hearing. At the diftance of three or four feet, a fmart ftroke, even upon a ftone wall, alarms and puts them to flight. But this may partly be attributed to the vibration in the wall, or the concuffion of the air, produced by the ftroke. To obviate this difficulty, at the fame diftance of between three and four feet, I ftruck the air repeatedly with a bookbinder's folder, without giving the fmalleft alarm to the flies. But, when I ftruck the folder againft the boards of a book, which I held in my hand, and made a fmart noife, the animals were inftantly alarmed, and flew off at the fecond ftroke. The fame effect is produced in a room juft light enough to render the animals vifible. Thefe trials, which I have often repeated, feem to indicate that flies, if they are really deprived of ears, are endowed with an analogous fenfe, though we are ignorant of its fituation.

Naturalifts

Naturalifts have limited the fenfes of infects to thofe of feeing and feeling. But the above remarks render it more than probable that flies poffefs likewife the fenfes of fmelling and of hearing: Neither fhould the fenfe of tafte be denied them; for, though they may be affifted by fmelling to difcover and felect their food, we cannot fuppofe that Nature has denied them the pleafure which other animals fo univerfally derive from eating. Befides, an agreeable fenfation, fimilar to that of tafte, muft accompany an action which removes the pain arifing from hunger.

The mouth of infects is generally placed in the under part of the head; but, in fome, it is fituated in the breaft. The jaws, inftead of being horizontal, are often tranfverfe, and furnifhed with teeth. The greater number of winged infects are provided with a probofcis or trunk, an inftrument by which they extract the juices from animal or vegetable fubftances. The probofcis of infects is a machine of a very complicated nature. In butterflies, the probofcis is fituated precifely between the two eyes. Though fome of them exceed three inches in length, they occupy but a fmall fpace. When a a butterfly is not in queft of food, the probofcis is rolled up in a fpiral form, fimilar to that of a watch-fpring, each fucceffive ring covering the one which precedes. The fubftance of the probofcis has fome refemblance to that of horn. It tapers from the bafe to the extremity. It is compofed of two fimilar and equal parts, each of which is concave, and, when joined, form three diftinct tubes. Reaumur has rendered it probable, that thefe tubes enable the animals to extract the juices of plants, to conduct air into their bodies, and to convey the fenfation of fmelling. Hence the probofcis of infects is an inftrument which ferves them for a mouth, a nofe, and a wind-pipe.

The upper part of the trunk or body of inſects is called the thorax, and the under part the abdomen or belly. The abdomen contains the ſtomach and other viſcera. It conſiſts of ſeveral rings or ſegments, and is perforated with ſpiracula, or tubes, which ſupply the want of lungs. The abdomen is terminated by the tail, which, in ſome inſects, is armed with a ſting, a forceps, a briſtle, or a kind of claw with a moveable thumb.

The legs are compoſed of three parts, connected to each other by joints, and repreſent the thighs, ſhanks, ankles, and feet of larger animals.

The wings of inſects are ſo diverſified in number, conſiſtence, and colour, that Linnaeus has made them the foundation of the ſeveral orders or diviſions into which he divides this numerous claſs of animals. Some inſects are furniſhed with four, and others with two wings, and ſome of them are entirely deſtitute of theſe inſtruments of motion.

The four-winged inſects are arranged into five orders. The *firſt* order Linnaeus diſtinguiſhes by the name of *coleoptera*, or thoſe inſects whoſe upper pair of wings conſiſt of a hard, cruſtaceous, or horny ſubſtance. Theſe cover and defend the under pair, which are of a more ſoft and flexible texture. This order comprehends the whole of what is properly called *ſcarabaei*, or the beetle tribe. Like other winged inſects, all the beetles live for ſome time in the form of caterpillars, or grubs.

As a farther confirmation of the connection of manners with form and ſtructure, it is here worthy of remark, that the ſame animals, when in the ſtate of caterpillars, live in a different manner, and feed on ſubſtances of a very different kind from thoſe they conſume after their transformation into flies. The caterpillars of the garden-beetle, cock-chafer, &c. lead a ſolitary life under ground, and conſume the roots of plants. Thoſe of others feed upon putrid carcaſſes, every kind of fleſh, dried ſkins, rotten wood, the dung of men and quadrupeds, and the ſmall inſects called *pucerons*, or *vine-fretters*. The devourers of the puceron contribute to cure ſuch plants as happen to be infected with the *phthiriaſis*, or louſy diſeaſe. But, after their transformation into flies, many of the ſame animals, which formerly fed upon dung and putrid carcaſſes, are nouriſhed by the pureſt nectareous juices extracted from fruits and flowers. The creatures themſelves, with regard to what may be termed *individual animation*, have ſuffered no alteration. But the fabrick of their bodies, their inſtruments of motion, and the organs by which they take their food, are materially changed. This change of ſtructure, though the animals retain their identity, produces the greateſt diverſity in their manners, their oeconomy, and the powers of their bodies. In the caterpillar ſtate, theſe animals are extremely voracious, and, in many inſtances, acquire a greater magnitude than they poſſeſs after transformation; but they are incapable of multiplying their ſpecies, and of receiving nouriſhment from the ſame kinds of food. Beſides, many caterpillars, previous to their transformation, live even in a different element. The ephemeron fly, when in the caterpillar ſtate, lives no leſs than three years in the water, and extracts its nouriſhment from earth and clay. After transformation, this animal ſeldom exiſts longer than one day, during which the ſpecies is propagated, and myriads of eggs are depoſited on the ſurface of the water. Theſe eggs produce worms or caterpillars, and the ſame proceſs goes perpetually round.

Linnaeus's *ſecond* order of inſects, or *hemiptera*, have likewiſe four wings. But the upper pair, inſtead of being hard and horny, rather reſemble fine vellum. They cover the body horizontally, and do not meet in a direct line, forming a ridge or future, as in the beetle tribe. The whole of this order are furnifhed with a proboscis or trunk for extracting their food.

This order comprehends feveral genera or kinds, fome of which we fhall mention in a curfory manner.—The *blatta, or cockroach*, is an animal which avoids the light, and is particularly fond of meal, bread, putrid bodies, and the roots of plants. It frequents bakers fhops and cellars, and flies the approach of danger with great fwiftnefs.—The head of the *mantis*, or *camel-cricket*, appears, from its continual nodding motion, to be flightly attached to the thorax. This infect is regarded by the Africans as a facred animal; becaufe it frequently affumes a praying or fupplicating pofture, by refting on its hind feet, and elevating and folding the firft pair.—The *gryllus* comprehends a number of fpecies, fome of which are called *grafshoppers*, others *locufts*, and others *crickets*. The *larvae*, or caterpillars of the grylli, have a great refemblance to the perfect infects, and, in general, live under ground. Many of thefe infects feed upon the leaves of plants. Others, which live in houfes, prefer bread, and every kind of farinaceous fubftance.—The *fulgora*, or firefly: The foreheads of feveral of this genus, efpecially of thofe that inhabit China, and other hot climates, emit a very lively fhining light during the night, which often alarms thofe who are unacquainted with the caufe of the appearance.—The *cicada*, *frog-hopper*, or *flea-locuft*: The *larvae*, or caterpillars, of fome of this genus, difcharge a kind of froth or faliva from the anus and pores of the body, under which they conceal themfelves from the rapacity of birds and other enemies.—The *papa* or *water fcorpion*, frequents ftagnant waters. It lives chiefly on aquatic infects, and is exceedingly voracious.—The *cimex* or bug: Many fpecies of this genus feed upon the juices of plants, and others upon the blood of animals. Some of them are found in waters, and others frequent houfes, among which, though it wants wings, is the bed-bug, a peftiferous infect, which is too well known, and too generally diffufed. The bugs differ from other infects by their foftnefs; and moft of them emit a very foetid fmell.—The *aphis*, *puceron*, or *vine-fretter:* Thefe infects are very common, and are generally termed the *lice* of the plants which they infeft: The puceron, as remarked in the firft chapter, is viviparous in fummer, and oviparous in autumn. Numbers of them are devoured by the ants, on account, as is fuppofed, of a fweet liquor with which their bodies are perpetually moiftened.—*Chermes:* The *larvae* or caterpillars of this infect have fix feet, and are generally covered with a hairy or woolly fubftance. The winged infects leap or fpring with great agility, and infeft a number of different trees and plants: The females, by means of a tube at the termination of their bodies, infert their eggs under the furface of the leaves, and the worms, when hatched, give rife to thofe tubercles, or galls, with which the leaves of the afh, the fir, and other trees, are fometimes almoft entirely covered.

The *third* order or tribe of four-winged infects confifts of three genera only. But the fpecies comprehended under them are exceedingly numerous. All butterflies and moths belong to this order. Their wings are covered with a farinaceous powder, or rather with a kind of fcales or feathers, difpofed in regular rows, nearly in the fame manner as tiles are laid upon the roofs of houfes. The elegance, the beauty, the variety of colours exhibited in their wings, are produced by the difpofition and different tinctures of thefe minute feathers. The infects of this order, on account of their beauty and eafy prefervation, have always been the favourites of collectors, and particularly of thofe of the female fex. When the feathers are rubbed off, the wings appear to be nothing more than a naked, and often a tranſparent membrane. The feelers of the *papilio*, or *butterfly*, are thickeſt at their extremity, and often terminate in a kind of capitulum, or head. Their wings, when ſitting, or at reſt, are erect, their extremities join each other above the body, and the animals fly about, in queſt of food and of their mates, during the day.—The *moths* are divided into two genera, the one called *ſphinx*, or *hawk moth*, and the other *phalaena*, or *moth*. The feelers of the *ſphinx* are thicker in the middle than at the extremities, and their form, in ſome meaſure, reſembles that of a priſm. The wings are, in general, deflected, their outer margins declining toward the ſides. They fly about early in the morning, and after ſun-ſet; and, by means of their proboſcis, like the butterflies, they ſuck the juices of plants.—The *phalaena*, or *moth:* The feelers of this genus are ſetaceous, and taper from the baſe to the point. When at reſt, their wings are commonly deflected; and they fly during the night. Previous to their transformation, the caterpillars of the whole of this genus ſpin webs for covering and protecting the animals while in the chryſalis ſtate. From a ſpecies of this tribe mankind have derived one of the greateſt articles of luxury and of commerce which now exiſts in the world. That ſeemingly contemptible, that diſguſting reptile known by the appellation of the *ſilk-worm*, in its paſſage from the caterpillar to the chryſalis ſtate, produces thoſe ſplendid materials which adorn the thrones of Princes, and add dignity and luſtre to female beauty *.

The wings of the *fourth* order, diſtinguiſhed by the name of *neuroptera*, are membranaceous, naked, and ſo interſperſed with delicate veins, that they have the appearance of beautiful net-work. Their tail has no ſting; but that of the male is frequently furniſhed with a kind of forceps or pincers. To this order belongs the *libella*, or *dragon-*

* See Chap. XI. concerning the Transformation of Animals.

dragon-fly, an inſect of very ſplendid and variegated colours. It is a large and well known fly, and frequents rivers, lakes, pools, and ſtagnating waters, in which the females depoſit their eggs. Their mode of generating is ſingular. Different ſpecies of them appear from the beginning of ſummer to the middle of autumn. They generally fly in pairs, and in a ſtraight line, the male purſuing the female. The organs of the male are ſituated in his breaſt: When he overtakes her, with the forceps in his tail he lays hold of her by the neck, while ſhe, by an inſtinctive impulſe, makes the lower end of her body approach the male organs. In this united ſituation they form a kind of ring, have the appearance of a double animal, and fly along till the purpoſe is accompliſhed. Under the ſame order is comprehended the *phryganea*, or *ſpring-fly*: The larvae or caterpillars of this genus live in the water, and are covered with a ſilken tube. They have a very ſingular aſpect; for, by means of a gluten, they attach to the tubes in which they are incloſed ſmall pieces of wood, ſand, gravel, leaves of plants, and not unfrequently live teſtaceous animals, all of which they drag along with them. They are very commonly found in ſalads of the water-creſs; and, as they are often entirely covered with green leaves, they have the appearance of animated plants. They are in great requeſt among fiſhermen, by whom they are diſtinguiſhed by the name of *ſtone*, or *cod-bait*. The fly, or perfect inſect, frequents running waters, in which the females depoſit their eggs.

The *fifth* order is termed *hymenoptera*. In general, the inſects belonging to this order have four membranaceous and naked wings. In ſome of the genera, however, the neuters, and, in others, the males, or even the females, have no wings. Their tails, except in the male ſex, are armed with a ſting.—The female of the *cynips*, an inſect belonging to this order, inſerts her eggs into the leaves of the oak, and the caterpillars produced from them give riſe to the

galls

galls employed in the compofition of ink.—This order likewife includes the wafp, the bee, and the ant. Many of the wafp kind, like the bees, live in fociety, make combs in which the females depofit their eggs, and feed their caterpillars with an inferior fpecies of honey. Others of them conftruct a feparate neft for each individual egg.—The bee is an infect too well known to require a particular defcription. The males have no fting; but the females, and the drones, or neuters, have a very fharp pointed fting concealed in their abdomen. The female of the honey bee is much larger than the male, or the neuter. Her feelers contain fifteen articulations. Her abdomen is compofed of feven fegments, and is much longer than her wings. The feelers of the male contain only eleven articulations. The neuters are much fmaller than the males or females, and their feelers confift of fifteen articulations.—The fting, with which the male and female *ants* are armed, is concealed within the abdomen. The males and females of the ant are furnifhed with wings, but the neuters are deprived of thefe inftruments of motion. The ants live in focieties which are compofed of males, females, and neuters. The males are much fmaller than the females and neuters. Soon after the males and females propagate the fpecies, they all die. Some of the neuters, however, furvive the winter; but they remain in their habitation without movement, or difcovering any figns of life. From thefe circumftances in the hiftory of ants, it is apparent, that the induftry and fagacity fo long and fo univerfally afcribed to thefe little animals could be of no ufe either to themfelves or their progeny. The female, after depofiting her eggs, takes no farther care of her offspring. But, what is fingular, the important office of feeding the *larvae*, or caterpillars, after the eggs are hatched, is left entirely to the neuters. This affectionate and affiduous attention of the neuters to a progeny neither begot nor brought forth by them, is fo aftonifhing, fo contrary to the general oeconomy of Nature, that no reafoning or theory can account

for

for a fact ſo uncommon, till farther diſcoveries ſhall be made in the hiſtory of theſe ſurpriſing animals. What is ſtill more ſingular, after the caterpillars are transformed into the chryſalis ſtate, the neuters are inceſſantly and anxiouſly employed in preſerving the chryſales from humidity when the weather is wet, and in expoſing them to the warmth of the ſun when it is fair. Theſe chryſales are larger than the animals themſelves, and yet they carry them off with eaſe and rapidity.

The *ſixth* order of inſects is termed *diptera*, or two-winged inſects. The different ſpecies of this order, beſide wings, are furniſhed with what is called a *halter*, or a *poiſer*, which is ſituated under each wing, and is terminated by a *capitulum*, or knob. This order comprehends ten genera and a multitude of ſpecies. The caterpillars of the *oeſtrus*, or *gad-fly*, lie concealed in the ſkins of cattle, where they are nouriſhed during the whole winter. The perfect inſects are frequent wherever horſes, cows, or ſheep, are grazing. Some of them depoſit their eggs in the ſkins of cows or oxen; others depoſit them in the inteſtines of horſes, to which they get acceſs by the anus; and others in the noſtrils of ſheep. In theſe habitations, the caterpillars reſide till they are full grown, when they throw themſelves down to the earth, and generally paſs the chryſalis ſtate under the firſt ſtone they meet with.—The *muſca*, or common *fly*: The mouth of this inſect conſiſts of a ſoft, fleſhy proboſcis, with two lateral lips. The caterpillars of ſome of this genus devour the pucerons; others conſume all kinds of putrid fleſh; others are found in cheeſe; others in the excrements of different animals; and many of them live in the water, and prefer that which is moſt corrupted and muddy.—The mouth of the *culex*, or *gnat* conſiſts of a flexible ſheath, incloſing four briſtles, or pointed ſtings. The feelers of the female gnat are plain like a thread; but thoſe of the male are beautifully feathered. The worms or caterpillars

caterpillars of this genus are commonly found in ftagnant waters. The gnats generally frequent woods and marfhy places. The females, in particular, are very troublefome, and fting feverely.—The feet of the *hippobofca*, or *horfe-fly*, are armed with a number of nails or crotchets. In fome fpecies, the wings crofs each other; in others, they are open. The horfe-flies frequent woods and marfhy grounds, and are extremely incommodious to birds and quadrupeds, whofe blood is the only food of thefe infects.

The *feventh* order of infects Linnaeus denominates *aptera*, becaufe neither males nor females are furnifhed with wings. This order comprehends thirteen genera, and a great number of fpecies, many of which are very offenfive and noxious to the human fpecies. The *pediculus*, or *loufe*, has fix legs, two prominent eyes, and its mouth contains a fting or fucker, by which it extracts blood and other juices from the bodies of animals. Though almoft every different animal is infefted with a peculiar fpecies of lice, the fpecific characters of very few of them have hitherto been afcertained. Lice are of various forms. Some of them are oval, others oblong, and others long and flender. They are oviparous animals, and their eggs are large in proportion to the fize of their bodies. Before they arrive at maturity, they change their fkin feveral times. They are fuppofed to be hermaphrodites. This circumftance, if true, may partly account for their prodigious multiplication. Swammerdam, who diffected a great number, affures us, that he never found one without an ovary, nor ever difcovered the organs peculiar to the male fex. If this ftructure be univerfal, the loufe is an hermaphrodite of a very peculiar kind; becaufe it muft be capable of foecundating itfelf. Several fpecies of worms are hermaphrodites; but, inftead of foecundating themfelves, they are obliged to impregnate each other.—The *pulex*, or *flea*, has likewife fix legs, the articulations of which are fo exceedingly elaftic, that the animal is enabled by their means, to ſpring to ſurpriſing diſtances. It has two fine eyes, and its body is covered with cruſtaceous ſcales. The flea is the only inſect belonging to this order which undergoes a transformation ſimilar to that of the former orders: All the other wingleſs inſects are produced in a perfect ſtate either by the mother, or from eggs. The caterpillars of the flea have forked tails, and are very ſmall and lively. They may be nouriſhed in boxes, and fed with flies, which they greedily devour. Before changing into the chryſalis ſtate, they live fourteen or fifteen days in the form of caterpillars.—*Aranea*, or ſpider: This genus comprehends a great many ſpecies. The ſpider has eight feet, and an equal number of immoveable eyes. The chief prey of the ſpider is flies, animals whoſe motions are extremely quick and deſultory. To enable the ſpider to obſerve their movements in every direction, ſhe is furniſhed with eight eyes, the poſition of which merits attention: Two of them are placed on the top of the head, other two on the front, and two on each ſide. The mouth is armed with two crotchets, by which it ſeizes and kills its prey. Round the anus there are ſeveral muſcular inſtruments, ſhaped like nipples or teats. Each of theſe contain about a thouſand tubes or outlets for threads ſo extremely minute, that many hundreds of them muſt be united before they form one of thoſe viſible ropes of which the ſpider's web is compoſed. The figure of the web varies according to the ſpecies, or the ſituation the animal chooſes for its abode. After the web is completed, ſome ſpecies reſide in the center, and others occupy the extremity of their habitations, where they lie in ambuſh, with aſtoniſhing patience, till an ill-fated fly is accidentally entangled. The ſpider, from the vibration of the threads, perceives his prey, ruſhes forth from his cell, inſtantly ſeizes it with his fangs, devours its vitals, and afterwards rejects the exhauſted carcaſe. Spiders prey upon all weaker inſects, and even upon their own ſpecies.—The *ſcorpion:* This venomous inſect is a native of warmer climates than thoſe of the north of Europe.

rope. It has eight feet, and two claws, the laſt of which are ſituated on the fore part of the head. Like the ſpider, the ſcorpion has eight eyes, three of which are placed on each ſide of the breaſt, and the other two on the back. The tail is long, jointed, and terminates in a ſharp crooked ſting. The venom of the ſcorpion is more deſtructive than that of any other inſect; and is ſometimes fatal in Africa and other hot regions.

The *laſt* diviſion of inſects is termed *vermes*, or *worms*, by Linnaeus. This claſs comprehends not only all the inſects commonly called *worms*, but all the teſtaceous animals, and the zoophites, or plant-animals. The ſtructure of ſeveral genera belonging to this claſs is extremely ſingular. After giving a few examples, we ſhall haſten to the concluſion of the preſent ſubject.

The body of the *gordius*, or *hair-worm*, is long, ſhaped like a thread or hair, ſmooth, and round. A ſpecies of the hair-worm is very common in our freſh waters, and is perfectly harmleſs. In Scotland, it is a vulgar and fooliſh notion, that the hair of a horſe's tail, when thrown into the water, is converted into this worm. Though inoffenſive in this country, the hair-worm of Africa, and of both the Indies, is extremely noxious. It is of a pale yellowiſh colour, and is frequently met with among the graſs, eſpecially when covered with dew. It often inſinuates itſelf into the naked feet or limbs of children and unwary perſons, where it produces an inflammation, which is ſometimes fatal. It may be extracted by tying a thread round its head, and then pulling it gently out of its abode. But this operation requires great caution; for, if the animal is broken, the part which remains does not die, but, in a ſhort time, regains what it had loſt, and becomes equally entire and troubleſome as if it had received no injury.—The *lumbricus*, or *earth-worm:* The body of this worm is cylindrical, conſiſts of many rings, and the middle is encompaſſed with an elevated belt. It is likewiſe furniſhed with ſharp prickles, which the animal can erect or depreſs at pleaſure. Through certain perforations in the ſkin, it occaſionally emits a ſlimy fluid, which lubricates its body, and facilitates its paſſage into the ſoil. The inteſtines of this worm are always filled with a fine earth, which ſeems to conſtitute its only nouriſhment. Earth-worms, like ſnails, are hermaphrodite. The parts of generation are placed near the neck, and they mutually impregnate each other. This operation is performed on the ſurface of the ground; and, while thus employed, they will allow themſelves to be cruſhed to pieces rather than part. The females depoſit their eggs in the earth, where they are hatched. Theſe worms, like the polypus, when cut through the middle, reproduce, and each portion becomes a diſtinct individual. According to the different periods of their growth, their colour varies; but, in general, it is a duſky red.

The *ſepia*, or *cuttle-fiſh*, though comparatively a large animal, ſome of them being two feet long, is ranked by Linnaeus under the claſs of *worms*. The ſtructure of the cuttle fiſh is remarkable. Its body is cylindrical, and, in ſome of the ſpecies, is entirely covered with a fleſhy ſheath; in others, the ſheath reaches only to the middle of the body. The ſepia has eight tentacula, or arms, beſide two feelers, as they are called, which are much longer than the arms. Both the feelers and arms are furniſhed with ſtrong cups, or ſuckers, ſhaped like the cup of an acorn, by means of which the animal ſeizes its prey, and firmly attaches itſelf to rocks, or to the bottom of the ſea. It has two large and prominent eyes. What is ſtill more ſingular, it is furniſhed with a hard, ſtrong, horny beak, preciſely ſimilar, both in texture and ſubſtance, to the bill of a parrot. With this bill, the cuttle-fiſh is enabled to break the ſhells of limpets, and other ſhell-animals, upon which it chiefly feeds. In the belly, there is an aperture through which the animal, when purſued by its enemies, emits a fluid as black as ink, tinges the water, and often efcapes by this ingenious ftratagem. The ancient Romans frequently ufed this black fluid as ink in writing. The males and females copulate by a mutual embrace. The female depofits her eggs upon fea-plants in parcels refembling bunches of grapes. At the inftant they drop from the mother, the eggs are white; but the male immediately coats them over with a black liquor. The male perpetually accompanies the female. When the female is attacked, he braves every danger, and often refcues her at the hazard of his own life. The bone of the cuttle-fifh is very light, and, when pulverized, it is employed by different artifts in making moulds.

The *medufa* is an animal which has the appearance of a lifelefs mafs of jelly floating on the furface of the ocean. Its body is roundifh, flattened underneath, and the mouth is fituated in the center of the under part. There are many fpecies of this feemingly moft imperfect, defencelefs, and abject part of animated nature. They are, however, furnifhed with tentacula, by which they feize infects and the fmall fry of fifhes, convey them to their mouths, and devour them. Although the fport of the waves, and the prey of every fifh that approaches them, they are gregarious animals, and, particularly in warm climates, fometimes collect in fuch numbers as to have the appearance of whitifh rocks under the furface of the ocean.

We have thus given a fhort fketch of the ftructure of animals, from man down to the infect tribes, and fhall now conclude with a few remarks.

In all the variety of animated beings whofe general ftructure has been exhibited, the intelligent reader will eafily perceive, that the bodily forms of the different kinds are exactly adapted to the rank they hold in the creation, and that their oeconomy and manners are ftrictly and invariably connected with their ftructure and organs. If a new animal appears, and if its figure be uncommon, it may with fafety be pronounced, that its manners are equally uncommon. Change the external or internal form of an animal; diminifh the number of ftomachs in the ruminating tribes; or give to the horfe a parot's bill; and the fpecies will be annihilated.

The comparative power, or ftrength, of animals depends not on ftructure alone. Mental faculties, and docility, or the capacity of receiving inftruction, feem to be the greateft fources of animal power. Hence man's unlimited empire over all other creatures. The inventions of language, of arms, of writing, printing, and engraving, have been the chief means of extending his influence, and of his acquiring the dominion of the earth. By thefe arts, men tranfmit the improvements, the inventions, and the acquifitions, of one age to another. By thefe arts, the difpofitions of men are foftened, their manners become more and more civilized, humanity is gradually extended and refined, and the groffer animofities yield to external politenefs and decorum at leaft, if the feelings themfelves be not blunted. How far this progrefs of fcience, and the peaceful arts of life, by the accumulation of ages, may proceed, it is impoffible to determine. But the time, it is to be hoped, is not very remote, when the fiercer contentions of nations will ceafe, when felfifhnefs and venality, which at prefent feem to be infeparable from commercial ftates, will give way to generofity of temper, and uprightnefs of conduct.

CHAPTER III.

Of the Respiration of Animals—Air necessary to the existence of all animated beings—The various modifications of the organs employed by Nature for the transmission of Air into animal bodies.

IT is foreign to the design of this chapter to mention the different kinds of air; to unfold its composition; or to recapitulate the innumerable benefits derived from it in the animal and vegetable kingdoms, in the arts of life, and in the texture and cohesion of inanimate bodies. For our purpose, it is sufficient to observe, that by *air* is meant that common elastic fluid which pervades this globe, and which by its weight, its pressure in all directions, and its compressibility, insinuates itself into every vacuity, and is necessary to the existence of every animal and vegetable being.

In man, and the larger land animals, air is taken into the body by the lungs. When an animal inspires, the external air passes through the apertures of the mouth and nose into the trachea or wind-pipe, and thence directly into the lungs. This air, by insinuating itself into the numerous cells of the lungs, necessarily inflates them, and, when retained for a second or two, produces an uneasy sensation. To remove this disagreeable feeling, the animal instinctively, by the exertion of particular muscles destined by Nature for

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that purpofe, forces out the air, and thus removes the offending caufe. The lungs, after the air is thrown out, inftead of being inflated, collapfe; and, if a frefh fupply is not foon taken in, a fimilar uneafy fenfation is felt, which obliges the animal again to infpire. This alternate reception and rejection of air goes on during the life of the animal, and is diftinguifhed by the general name of *refpiration*. But, when treating more accurately of the fubject, the act of taking air into the lungs is called *infpiration*, and the act of throwing it out is termed *expiration*.

That the refpiration of air is indifpenfible to the exiftence of land-animals, has been proved by innumerable experiments made with the air-pump. Mice, rats, rabbits, cats, dogs, &c. when placed in an exhaufted receiver, inftantly become reftlefs, and difcover fymptoms of pain. Their bodies fwell, and their life is foon extinguifhed. Indeed, our own feelings are fufficient to afcertain this fact. No perfon can remain long either in a ftate of infpiration or expiration without being fuffocated.

But the alternate motions of infpiration and expiration, joined to the circulation of the blood through the lungs, may be confidered as the more mechanical effects of refpiration. Though thefe operations are abfolutely neceffary to the exiftence of animals, yet the air itfelf has been fuppofed to impart fome vital principle to the blood, without which life could not be continued.

The ingenious Doctor Crawford, in his treatife on Animal Heat, has rendered it probable, that the refpiration of air is the caufe of that vital warmth without which no animal can exift. After mentioning a well known fact, that all bodies, whether animate or inanimate, contain a certain quantity of fire as a principle in their compofition, the Doctor remarks, that this quantity, in different bodies,

dies, varies according to their nature or texture; that this fire, when in a latent or quiefcent ftate, is termed *abfolute heat;* that, when fubftances of different textures have a given quantity of heat thrown into them, their temperature will be difcovered to be different by the thermometer; for the fame quantity of heat which raifes one body to a certain degree, will raife another to a greater or a lefs; and this different difpofition of bodies is called their capacity of containing abfolute heat.

Doctor Crawford next endeavours to prove by experiments, that, when phlogifton is added to any body, its capacity of containing abfolute heat is diminifhed; and that, when phlogifton is abftracted from the fame body, its capacity of receiving abfolute heat is augmented. Hence he infers, that heat and phlogifton feem to conftitute two oppofite principles in nature By the action of heat upon bodies, the force of their attraction to phlogifton is diminifhed; and, by the action of phlogifton, a part of the abfolute heat, which exifts in every fubftance as an element, is expelled. 'Hence,' fays the Doctor, 'animal heat feems to depend upon a procefs fimilar to 'a chemical elective attraction. The air is received into the lungs, 'containing a great quantity of abfolute heat. The blood is re'turned from the extremities, highly impregnated with phlogifton. 'The attraction of the air to the phlogifton is greater than that of 'the blood. This principle will therefore leave the blood to com'bine with the air. By the addition of the phlogifton, the air is 'obliged to depofit a part of its abfolute heat; and, as the capacity 'of the blood is, at the fame moment, increafed by the feparation 'of the phlogifton, it will inftantly unite with that portion of heat 'which had been detached from the air.

'We learn from Doctor Prieftley's experiments with refpect to 'refpiration, that arterial blood has a ftrong attraction to phlogifton:

'It will, confequently, during the circulation, imbibe this principle 'from thofe parts which retain it with the leaft force, or from the 'putrefcent parts of the fyftem: And hence the venous blood, when 'it returns to the lungs, is found to be highly impregnated with 'phlogifton. By this impregnation, its capacity for containing heat 'is diminifhed. In proportion, therefore, as the blood, which had 'been dephlogifticated by the procefs of refpiration, becomes again 'combined with phlogifton, in the courfe of the circulation, it will 'gradually give out that heat which it had received in the lungs, 'and diffufe it over the whole fyftem *.'

The Doctor afterwards proceeds to affign a reafon why the heat of animals is always equal. 'As animals,' fays he, 'are continu-'ally abforbing heat from the air, if there were not a quantity of 'heat carried off, equal to that which is abforbed, there would be an 'accumulation of it in the animal body. The evaporation from 'the furface, and the cooling power of the air, are the great caufes 'which prevent this accumulation. And thefe are alternately in-'creafed and diminifhed, in fuch a manner as to produce an equal 'effect. When the cooling power of the air is diminifhed by the 'fummer heats, the evaporation from the furface is increafed; and 'when, on the contrary, the cooling power of the air is increafed 'by the winter colds, the evaporation from the furface is propor-'tionally diminifhed †.'

This theory, though not fupported by mathematical evidence, is not only ingenious, but feems to make a nearer approach to truth than any that has hitherto been invented ‡.

Refpiration,

* Crawford on Animal Heat, pag. 73. † Ibid. pag. 84.

‡ If the reader is defirous of feeing fome pertinent remarks on Doctor Crawford's Theory

Reſpiration, beſide being the probable cauſe of the equable continuation of heat in animals, produces many other ſalutary and uſeful effects in the oeconomy of animated bodies. There is a moſt intimate connection between the act of reſpiring and the circulation of the blood. When reſpiration is, for a ſhort time, interrupted by the fumes of burning ſulphur, by mephitic air, or by remaining ſome minutes under water, the action of the heart ceaſes. But, in many caſes of this kind, the motion of the heart may, and frequently has been renewed, by blowing air into the lungs, and by the application of ſtimulating ſubſtances to different organs of the body. In perſons ſeemingly dead from a temporary ſuſpenſion of reſpiration, if the lungs can be excited to act, the motion of the heart inſtantly commences, the circulation of the blood is reſtored, and life is recovered. This intimate connection between reſpiration and the action of the heart, is one of thoſe aſtoniſhing facts in the animal oeconomy, the cauſes of which will perhaps forever elude the keeneſt reſearches of the human intellect. All we know is, that certain functions are indiſpenſible to the exiſtence of animals, and that, if any of them are ſuſpended for a few ſeconds, life is extinguiſhed; namely, the action of the brain and nerves, the circulation of the blood, reſpiration, and a probable reſult of reſpiration, animal heat. Theſe functions, from their importance in the ſyſtem, have received the appellation of *vital functions*. There are other functions of the body, called *natural*, which are no leſs neceſſary to life, as the digeſtion and concoction of aliment, the various ſecretions and excretions. But they are diſtinguiſhed from the vital functions, becauſe ſome of them may be ſuſpended for a conſiderable time without materially injuring the body.

 Reſpiration

Theory of Animal Heat, he may conſult Doctor Gardiner's *Obſervations on the Animal Oeconomy, and on the Cauſes and Cure of Diſeaſes*, an ingenious and uſeful performance, lately publiſhed, and which merits much more attention from Philoſophers and Phyſicians than it has hitherto received.

Reſpiration commences inſtantly after birth, and is inſtinctively continued during life. In the foetus ſtate, as formerly mentioned *, reſpiration is unneceſſary, becauſe the circulation of the general maſs of blood is carried on through a different channel. In the act of inſpiration, we are conſcious of making a certain effort; but in the act of expiration we ſcarcely perceive any exertion whatever.

Beſide the circulation of the blood, and the continuation of the vital warmth, reſpiration gives riſe to many other important functions in the animal oeconomy. All animals who reſpire, beſide a watery vapor, exhale great quantities of mephytic or corrupted effluvia, which, if retained in the lungs, or breathed by other animals, would ſoon prove fatal. The muſcles of reſpiration, of which we have the command, are employed in many other operations of the body, beſide the mere act of breathing air. All animals furniſhed with lungs expreſs their wants, their affections and averſions, their pleaſures and pains, either by words, or by ſounds peculiar to each ſpecies. Theſe different ſounds are produced by ſtraitening or widening the glottis and wind-pipe, or, in general, the paſſage through which the air paſſes in reſpiration. The inferior animals are by this means enabled to expreſs themſelves, though not by articulate ſounds, in ſuch a manner as to be perfectly intelligible to every individual of a ſpecies. On man alone, Nature has beſtowed the faculty of ſpeaking, or of expreſſing his various feelings and ideas, by a regular, extenſive, and eſtabliſhed combination of articulate ſounds. To have extended this faculty to the brute creation, would not, it is probable, have been of any uſe to them; for, though ſome animals can be taught to articulate, yet, from a defect in their intellect, none of them ſeem to have any idea of the proper meaning of the words they utter. Speech is performed by a very various and

* See above, page 66.

and complicated machinery. In ſpeaking, the tongue, the lips, the jaws, the whole palate, the noſe, the throat, together with the muſcles, bones, &c. of which theſe organs are compoſed, are all employed. This combination of organs we are taught to uſe when ſo young that we are hardly conſcious of the laborious taſk, and far leſs of the manner by which we pronounce different letters and words. The mode of pronouncing letters and words, however, may be learned by attentively obſerving the different organs employed by the ſpeaker. By this means we are enabled to correct various defects of ſpeech, and even to teach the dumb to ſpeak; for dumbneſs is ſeldom the effect of imperfection in the organs of ſpeech, but generally ariſes from a want of hearing; and it is impoſſible for deaf men to imitate ſounds which they never heard, except they be taught to uſe their organs by viſion and by touching.

When about to laugh, we make a very full inſpiration, which is ſucceeded by frequent, interrupted, and ſonorous expirations. When the titillation is great, whether it ariſes from the mind or body, theſe convulſive expirations ſometimes interrupt the breathing to ſuch a degree as to endanger ſuffocation. Moderate laughing, on the contrary, promotes health: By agitating the whole body, it quickens the circulation of the blood, gives an inexpreſſible chearfulneſs to the countenance, and baniſhes every kind of anxiety from the mind.

In weeping, we employ nearly the ſame organs as in laughing. It commences with a deep inſpiration, which is ſucceeded by ſhort, broken, ſonorous, and diſagreeable expirations. The countenance has a diſmal aſpect, and tears are poured out. Weeping originates from grief, or other painful ſenſations either of body or mind: When full vent is given to tears, grief is greatly alleviated. Both laughing and weeping have been reckoned peculiar to man. But this notion ſeems not to be well founded. Though the other animals exprefs not their pleafures or pains in the fame manner as we do, yet all of them exhibit their pleafant or painful feelings by fymptoms or cries, which are perfectly underftood by the individuals of each fpecies, and, in many inftances, by man. A dog, when hurt, complains in the bittereft terms; and, when he is afraid, or perhaps melancholy, he expreffes the fituation of his mind by the moft deplorable howlings. A bird, when fick, ceafes to fing, droops the wing, abftains from food, affumes a lurid afpect, utters melancholy, weak cries, and exhibits every mark of depreffed fpirits. By this means, animals intimate the affiftance they require, or foften thofe who maltreat them. Their plaintive cries are fometimes fo affecting as to difarm their enemies, or procure the aid of their equals. On the other hand, when animals are pleafed or careffed, they difcover, by their countenance, by their voice, by their movements, unequivocal fymptoms of chearfulnefs and alacrity of mind. Thus the expreffions of pleafure and pain by brute animals, though not uttered in the precife manner with thofe of the human fpecies, are perfectly analogous, and anfwer the fame intentions of Nature.

By refpiration, and the inftruments employed in the performance of it, the larger animals are not only brought forth, but are enabled to extract milk from the breafts of the mother. By refpiration, odors are conveyed to the nofe; coughing, fneezing, yawning, fighing, finging, vomiting, and many other functions in the animal oeconomy, are at leaft partly accomplifhed.

After this general view of the refpiration of man and of quadrupeds, we proceed, according to the method laid down, to give fome account of the fame function in the other claffes of animals.

With regard to BIRDS, though, like other land-animals, they refpire by means of lungs, Nature has enabled them to tranfmit air to almoft almoſt every part of their bodies. The lungs of birds are ſo firmly attached to the diaphragm, the ribs, the ſides, and the vertebrae, that they can admit of very little dilatation or contraction. Inſtead of being impervious, the ſubſtance of the lungs, as well as of the diaphragm, to which they adhere, is perforated with many holes or paſſages for the tranſmiſſion of air to the other parts of the body *. To each of theſe perforations a diſtinct membranous bag is joined. Theſe bags are extremely thin and tranſparent. They extend through the whole of the abdomen, are attached to the back and ſides of that cavity, and each of them receives air from their reſpective openings into the lungs. The cells in birds which receive air from the lungs are found not only in the ſoft parts, but in the bones. That ingenious and accurate anatomiſt, Mr John Hunter of London, remarks, that the bones of birds which receive air are of two kinds: 'Some, as the ſternum, ribs, and vertebrae, have their internal ſubſtance divided into innumerable cells, whilſt others, as the os humeri and the os femoris, are hollowed out into one large canal, with ſometimes a few bony columns running acroſs at the extremities. Bones of this kind may be diſtinguiſhed from thoſe that do not receive air by certain marks: 1. By their leſs ſpecific gravity: 2. By being leſs vaſcular, and therefore whiter: 3. By their containing little or no oil, and conſequently being more eaſily cleaned; and, when cleaned, appearing much whiter than common bones: 4. By having no marrow, or even any bloody pulpy ſubſtance in their cells: 5. By not being, in general, ſo hard and firm as other bones; and, 6. By the paſſage that allows the air to enter the bones, which can eaſily be perceived. In the recent bone we may readily diſcover holes, or openings, not filled with any ſuch ſoft ſubſtance as blood-veſſels or nerves; and it happens 'that

* This fact ſeems to have been firſt mentioned by the celebrated Doctor Harvey. See Harvey de Generat. Animal. Exercit. 3.

'that ſeveral of theſe holes are placed together, near that end of the 'bone which is next to the trunk of the bird; and are diſtinguiſh-'able by having their external edges rounded off; which is not the 'caſe with the holes through which either nerves or blood-veſſels 'paſs into the ſubſtance of the bone *.'

Mr Hunter afterwards informs us, that the lungs, at the anterior part, open into a number of membranous cells, which lie upon the ſides of the pericardium, and communicate with thoſe of the ſternum. At the ſuperior part, the lungs open into the large cells of a looſe net-work, through which the wind-pipe, gullet, and large veſſels, paſs as they proceed to and from the heart. Theſe cells, when diſtended with air, augment conſiderably the part where they are ſituated; and this augmentation, or ſwelling, is generally a mark either of anger or of love. This tumefaction is remarkable in the turkey-cock, in the pouting pigeon, and in the breaſt of a gooſe when ſhe cackles. Theſe cells communicate with others in the axilla, under the large pectoral muſcle. In moſt birds, the axillary cells communicate with the cavity of the os humeri by ſmall openings in the hollow ſurface near the head of that bone. In ſome birds, theſe cells are continued down the wing, and communicate with the ulna and radius; in others, they extend even to the pinions. The poſterior edges of the lungs open into the cells of the vertebrae, into thoſe of the ribs, the canal of the ſpinal marrow, the ſacrum, and other bones of the pelvis; from theſe parts the air finds a paſſage into the thigh-bone. 'Thus,' continues our learned and indefatigable author, 'the cells of the abdomen, thoſe ſurrounding 'the pericardium, thoſe ſituated at the lower and forepart of the 'neck, and in the axilla, thoſe in the cellular membrane under the 'pectoral muſcles, as well as in that which unites the ſkin to the 'body,

* Hunter's Obſervations on certain parts of the Animal Oeconomy, pag. 79.

'body, all communicate with the lungs, and are capable of being 'filled with air; and again from theſe the cells of the ſternum, ribs, 'vertebrae of the back and loins, bones of the pelvis, the humeri, 'the ulna and radius, with the pinions and thigh-bones, can in many 'birds be furniſhed with air *.'

Theſe facts, which our author candidly acknowledges had been formerly obſerved, led him, in the year 1758, to make experiments on the breathing of birds, in order to prove the free communication between the lungs and the ſeveral parts of the body mentioned above.

'Firſt,' ſays he, 'I made an opening into the belly of a cock, 'and having introduced a ſilver canula, tied up the trachea; I found 'that the animal breathed by this opening, and might have lived; 'but, by an inflammation in the bowels coming on, adheſions were 'produced, and the communication cut off.

'I next cut the wing through the os humeri, in another fowl, 'and tying up the trachea, as in the cock, found that the air paſſed 'to and from the lungs by the canal in this bone. The ſame expe'riment was made with the os femoris of a young hawk, and was 'attended with nearly the like ſucceſs †.'

The extreme ſingularity of this almoſt univerſal diffuſion of air through the bodies of birds, naturally excited a deſire to diſcover what might be the intention of Nature in producing a ſtructure ſo extraordinary. Mr Hunter firſt imagined that it might be intended to aſſiſt the act of flying, by increaſing the volume and ſtrength of

* Hunter's Obſervations on certain parts of the Animal Oeconomy, pag. 81.

† Ibid. pag. 82.

the animal, without adding to its weight, which muſt be diminiſhed; becauſe the ſpecific gravity of the external air is ſuperior to that of the internal air, which is rendered more rare by the heat of the animal's body. This opinion was corroborated, by conſidering that the feathers of birds, and particularly thoſe of the wings, contain a great quantity of air. With his uſual ingenuouſneſs, however, Mr Hunter, in oppoſition to his firſt conjecture, informs us, that the oſtrich, which does not fly, was amply provided with air-cells diſperſed through its body; that the wood-cock, and ſome other flying birds, were not ſo liberally ſupplied with theſe cells as the oſtrich; and that the bat had no ſuch peculiarity of ſtructure. With regard to the oſtrich, though it is not intended to fly, it runs with amazing rapidity, and, conſequently, requires ſimilar reſources of air.

He next conjectured, from analogy, that the air-cells in birds ought to be conſidered as an appendage to the lungs; becauſe in the ſnake, viper, and ſeveral other amphibious animals, the lungs are continued, in the form of two bags, through the whole abdomen, the upper part of which can only perform the office of reſpiration with any degree of effect; becauſe the lower part has comparatively few air-veſſels. 'The air,' ſays Mr Hunter, 'muſt paſs through 'this upper part before it gets to the lower in inſpiration, and muſt 'alſo repaſs in expiration; ſo that the reſpiratory ſurface has more 'air applied to it than what the lungs of themſelves could contain. 'There is, in fact, a great ſimilarity between birds and that claſs of 'animals called *amphibious;* and, although a bird and a ſnake are 'not the ſame in the conſtruction of the reſpiratory organs, yet the 'circumſtance of the air paſſing in both beyond the lungs, into the 'cavity of the abdomen, naturally leads us to ſuppoſe, that a ſtructure ſo ſimilar is deſigned in each to anſwer a ſimilar purpoſe. This 'analogy is ſtill farther ſupported by the lungs in both conſiſting of 'large cells. Now, in amphibious animals, the uſe of ſuch a con-

'formation

' formation of lungs is evident; for it is in consequence of this ' structure that they require to breathe less frequently than others. ' Even considering the matter in this light, it may still, in birds, ' have some connection with flying, as that motion may easily be ' imagined to render frequency of respiration inconvenient, and a ' reservoir of air may therefore become singularly useful. Although ' we are not to consider this structure in birds to be an extension of ' lungs, yet I can easily conceive this accumulation of air to be of ' great use in respiration; for, as we observed in the viper, that the ' air, in its passage to and from these cells, must certainly have a ' considerable effect upon the blood in the lungs, by allowing a much ' greater quantity of air to pass in a given time, than if there was ' no such construction of parts. And this opinion will not appear ' to be ill founded, if we consider, that, both in the bird and the vi- ' per, the surface of the lungs is small in comparison to what it is ' in many other animals which have not this extension of cavity.— ' We must not, however, give up the idea of such structure being ' of use in flying; for I believe we may set it down as a general ' rule, that, in the birds of longest and highest flight, as eagles, this ' extension, or diffusion of air, is carried farther than in the others; ' and this opinion is strengthened, by comparing this structure with ' the respiratory organs in the flying insects, which are composed of ' cells diffused through the whole body; and these are extended ' even into the head and down the extremities, while there is no ' such structure in those that do not fly, as the spider,' &c.

Though Mr Hunter's modesty has not permitted him to draw his conclusion in a positive manner, he seems to have proved decidedly, that one use of the general diffusion of air through the bodies of birds is to prevent their respiration from being stoped or interrupted by the rapidity of their motion through a resisting medium. The resistence of the air increases in proportion to the celerity of the motion. Were it poffible for man to move with a fwiftnefs equal to that of a fwallow, the refiftance of the air, as he is not provided with internal refervoirs fimilar to thofe of birds, would foon fuffocate him. Neither does the difficulty he mentions, with regard to the ftructure of the oftrich, feem to contradict his theory; for though, as formerly remarked, the oftrich does not fly, he runs with aftonifhing rapidity.

The refpiration of air is not only neceffary to the exiftence of land-animals, but to that of FISHES of every denomination. Coetaceous fifhes, or thofe of the whale-kind, refpire, like man and quadrupeds, by means of lungs; and, of courfe, they are obliged, at certain intervals, to come to the furface, in order to throw out the former air, and to take in a frefh fupply.

Inftead of lungs, the other fpecies of fifhes are furnifhed with gills, through which they refpire both water and air; for air is univerfally diffufed or mixed with every portion of water. When a free communication with the external air is prevented by ice, or by artifice, fifhes immediately difcover fymptoms of uneafinefs, and foon perifh. Ælian informs us, that, in winter, when the river Ifter was frozen, the fifhers dug holes in the ice; that great numbers of fifhes reforted to thefe holes; and that their eagernefs was fo great, that they allowed themfelves to be feized by the hands of the fifhermen. Rondeletius made many experiments on this fubject. If, fays he, fifhes are put into a narrow-mouthed veffel filled with water, and a communication with the air be preferved, the animals live, and fwim about, not for days and months only, but for feveral years. If the mouth of the veffel, however, be fo clofely fhut, either with the hand, or any other covering, that the paffage of the air is excluded, the fifhes fuddenly die. Immediately after the mouth of the veffel is clofed, the creatures rufh tumultuoufly, one above another,

other, to the top, contending which of them ſhall ſooneſt receive the benefit of the air *. In the ſhallow parts of rivers, when frozen, many fiſhes are found dead. But, when parts of a river are deep or rapid, the fiſhes fly from the ice, and by this means avoid deſtruction.

Theſe, and ſimilar experiments, have been repeated by Mr Willoughby, and many other modern authors; and they have uniformly been attended with the ſame event. A carp, in a large veſſel full of water, was placed in the receiver of an air-pump. In proportion as the air was exhauſted by working the pump, the ſurface of the animal's body was covered with a number of bubbles. The carp ſoon breathed quicker, and with more difficulty: A little after, it roſe to the ſurface in queſt of air. The bubbles on its ſurface next diſappeared; the belly, which before was greatly ſwollen, ſuddenly collapſed; and the animal ſunk to the bottom, and expired in convulſions.

Thus the reſpiration of air is as neceſſary to the exiſtence of fiſhes as to that of land-animals; for none of them can live long when deprived of this vivifying element. Fiſhes, indeed, ſeem to require a ſmaller quantity of air than animals who have a conſtant and free communication with the atmoſphere. The bodies and fluids of fiſhes are colder than thoſe of land-animals; and, of courſe, if Doctor Crawford's theory be well founded, fiſhes require leſs air to ſupport the proportionally ſmall quantity of heat they poſſeſs.

An analogy between fiſhes and birds deſerves here to be noticed. Both of theſe claſſes of animals are rapid in their motions; and both of them, beſide reſpiring by lungs or gills, have receptacles of air within their bodies. Fiſhes tranſmit ſmall quantities of air through their

* Rondeletius, lib. 4. cap. 9.

their gills; but Nature has provided moſt of them with air-bags or bladders, which may anſwer the double purpoſe of enabling them to aſcend and deſcend in the water, and to communicate a vital principle to their whole ſyſtem.

We ſhall conclude this ſubject with an account of the modes employed by Nature for tranſmitting air into the bodies of INSECTS.

In this ſeemingly contemptible, and often noxious claſs of animals, Nature has exhibited a wonderful diverſity of form, of manners, of inſtincts, of deformity, and of beauty. But, however inſignificant theſe creatures may appear to inattentive obſervers, Nature has been equally provident in the formation of their bodies, and in the means of preſerving the different individuals, according to their kinds, as in the larger animals, which have the appearance of more importance in the ſcale of being. To inſects ſhe has denied lungs ſimilar to thoſe of men, quadrupeds, birds, and fiſhes; but, as the tranſmiſſion of air into their bodies was neceſſary to continue the principle of life, ſhe has furniſhed them with peculiar inſtruments and apparatus for accompliſhing this indiſpenſible purpoſe.

Air is conveyed into the bodies of inſects by inſtruments called *tracheae* or *ſtigmata*. The tracheae, or wind-pipes, are, in many inſects, long tubes protruding externally from different parts of the body. In ſome, they proceed from the poſterior part, and have the appearance of one, two, or three tails; in others, they ariſe from the back or ſides. The *ſtigmata* are ſmall holes, generally of a different colour from the reſt of the body, and run along the ſides of many caterpillars in regular and beautifully dotted lines. That theſe tracheae and ſtigmata are deſtined for the tranſmiſſion of air, has been proved by repeated experiments; for, when ſtopped up by the application

application of oil, or other unctuous ſubſtances, the animals ſoon loſe their exiſtence.

In contemplating the parts of animals, when the uſes of theſe parts are not apparent, we are apt to deceive ourſelves by raſhly ſuppoſing them to anſwer purpoſes for which they were never intended by Nature. Impreſſed with this idea, M. de Reaumur was not ſatisfied with the notion of Goedart and others, that the long tails of certain worms were intended to keep them ſteady in their motions, and to prevent them from rolling. Reaumur obſerved, that theſe worms or grubs could lengthen or ſhorten their tails at pleaſure, but that they were always longer than the animal's body. Becauſe theſe tails have ſome reſemblance to that of a rat, he diſtinguiſhes the animals by the name of *rat-tailed worms*. Theſe worms are aquatic, and never appear on dry ground till they are about to undergo their firſt transformation. Reaumur, in order to obſerve their oeconomy more cloſely, collected a number of rat-tailed worms, and put them into a glaſs veſſel filled two inches high with water. At firſt they were conſiderably agitated, each ſeemingly ſearching for a proper place of repoſe. Some of them ſwam acroſs, others attached themſelves to the ſides, and others reſted at the bottom of the veſſel. In a quarter of an hour they were almoſt entirely tranquil, and Reaumur ſoon diſcovered the real uſe of their long tails. Upon examining the veſſel, he found that each of the animals, in whatever ſituation they were placed, extended its tail exactly to the ſurface; that, like other aquatic inſects, the reſpiration of air was neceſſary to their exiſtence; and that the tail, which is tubular, and open at the extremity, was the organ by which this operation was performed. In this experiment, the diſtance from the bottom to the ſurface was two inches, and, of courſe, the tails were of an equal length. To diſcover how far the animals could extend their tails, this moſt ingenious and indefatigable philoſopher gradually augmented the height

 of

of the water, and the tails uniformly rofe to the furface till it was between five and fix inches high. When the water was raifed higher, the animals immediately quitted their ftation at the bottom, and either mounted higher in the water, or fixed upon the fides of the veffel, in fituations which rendered it convenient for them to reach the furface with the points of their tails. Thefe tails confift of two tubes, both of which are capable of extenfion and contraction. The firft tube is always vifible; but the fecond, which is the proper organ of refpiration, is exferted only when the water is raifed to a certain height. Through this tube the air is conveyed into two large tracheae or wind-pipes within the body of the animal, and maintains the principle of life. When the tails are below the furface, they occafionally emit fmall bubbles of air, which are vifible to the naked eye; and immediately repair to the furface for frefh fupplies. Thefe rat-tailed worms pafs the firft and longeft part of their lives under water; when near the time of their transformation, they leave the water, go under the ground, and are there transformed into chryfalids; and, laftly, from this ftate they are transformed into flies, and fpend the remainder of their exiftence in the air.

Another fpecies of aquatic worms merit attention. They frequent marfhes, ditches, and ftagnating waters. Their general colour is a greenifh brown. Their bodies confift of eleven rings; and their fkin is not cruftaceous, but rather refembles parchment. Though thefe animals, before their transformation into flies, live in water, air is neceffary to fupport their principle of life; and the apparatus with which Nature has furnifhed them for that important purpofe deferves our notice. The laft ring, or termination of their bodies, is open, and ferves as a conductor of air. From this laft ring proceed a number of hairs, which, when examined by the microfcope, are found to be real feathers with regular vanes. In particular fituations, they bend the laft ring in fuch a manner as to reach the

 furface

furface of the water or mud in which they are placed. Thefe feathers prevent the water from entering into the tube, or organ of refpiration; and, when the animal raifes the termination of its body to the furface, in order to receive air, it erects and fpreads the feathers, and by this means expofes the end of the tube to the atmofphere. When cautioufly cut open, two large veffels, or tracheae, appear on each fide, and occupy almoft one half of the body. Both of thefe wind-pipes terminate in the open tube, or laft ring. Though thefe worms are furnifhed with organs of refpiration, and actually refpire air, yet M. de Reaumur difcovered that fome of them could live more than twenty-four hours without refpiration.

So anxious is Nature to provide animals, in every ftate of their exiftence, with air, that, after the transformation of many infects into chryfalids, fhe creates inftruments for that purpofe, which did not exift previous to their transformation. The rat-tailed worms, formerly mentioned, foon after they are transformed into chryfalids, inftead of a foft pliable fkin, are covered with a hard cruftaceous fubftance, feemingly impervious to the air; and the tail, which was the wind-pipe of the animal in its firft ftate, gradually vanifhes. In a few hours, however, four hollow horns fhoot out, two from the fore, and two from the hind, part of what was the head of the animal. Thefe horns, which are hard and tubular, M. de Reaumur difcovered to be real wind-pipes, deftined for the introduction of air into the chryfalis, a ftate in which the animals have the appearance of being almoft totally dead, and, of courfe, fhould feem to have little ufe for refpiration. He likewife difcovered that thefe horns, which had pierced the hard exterior covering, terminated in as many tracheae in the body of the animal. This fact affords a ftrong example of the neceffity of air for fuftaining the principle of life, even in its loweft condition. After thefe animals pafs from the chryfalis ftate to that of flies, they are deprived both of their tails and horns.

But Nature, in this laſt ſtage of their exiſtence, has not left them without proper reſources for the introduction of air into their bodies. Inſtead of protuberant tracheae in the form of tails or horns, they now, like other flies, receive air by means of ſtigmata, or holes, variouſly diſpoſed over different parts of the body.

The nymph of the libella, or dragon-fly, reſpires water, in the ſame manner as men and quadrupeds reſpire air. We receive and throw out the air by the mouth and noſtrils. But the nymphs of the libella receive and eject water by an aperture at the termination of their bodies. Theſe nymphs ſometimes throw out the water, at certain intervals, with ſuch force, that the ſtream is perceptible at the diſtance of two or three inches from their bodies. When kept ſome time out of the water, the deſire or neceſſity of reſpiration is augmented; and, accordingly, when replaced in a veſſel filled with water, inſpirations and reſpirations are repeated with unuſual force and frequency. If you hold one of theſe nymphs in your hand, and apply drops of water to the poſterior end of its body, it inſtantly, by an apparatus ſimilar to the piſton of a pump, ſucks in the water, and the dimenſions of its body are viſibly augmented. This water is again quickly thrown out by the ſame inſtrument. But, though this inſect reſpires water, air ſeems to be not the leſs neceſſary to its exiſtence; for, like other inſects, the whole interior part of its body is amply provided with large and convoluted tracheae; and, externally, there are ſeveral ſtigmata deſtined for the introduction of air *.

The worms, or nymphs, of the ephemeron flies merit attention. They have received the denomination of *ephemeron*, becauſe almoſt none of them ſurvive the day in which they are transformed into flies.

* Reaumur, tom. 12. pag. 187. 12° edit.

flies. But many of them live not one hour after their transformation. When in the worm and nymph ftates, they generally live in holes near the furface of the water; and, under thefe two forms, continue to grow till they are mature for paffing into the laft and fhorteft period of their exiftence. Swammerdam informs us, that fome of them remain three years under water, others two, and others one only. During their abode in this element, they are nourifhed and prepared for their laft and fatal change. Immediately after the males have joined their mates, and the females have depofited their eggs in the water, both perifh, but not before they have left the rudiments of a numerous race of fucceffors. As long as thefe infects live in the water, to inattentive obfervers, their general appearance is nearly the fame. When they have paffed, however, into nymphs, the veftiges of wings may be perceived, which we look for in vain during their firft or worm ftate. In both ftates, the infect which is to become an ephemeron fly has fix legs attached to the breaft. The head is triangular, and from the bafe of each eye proceeds an articulated feeler. The body is compofed of ten rings, from the laft of which three tails, that probably perform the office of tracheae, arife. Thefe tails, in fome fpecies, are as long as the animal's body, and are fringed with hairs which have a refemblance to feathers. But, what principally deferves our notice on this fubject is, that, on each fide of the body, there are fix or feven protuberances, which have the appearance of fo many oars. With thefe inftruments the animals defcribe arches in the water, firft on one fide, and then on the other, with aftonifhing rapidity. This circumftance led Clutius, and fome other authors, to think that thefe protuberances were fins, or inftruments of motion, and that the animals were fifhes. But Reaumur remarked that they moved thefe fins with the fame rapidity when the animals were at reft as when they were in motion; and that, inftead of fins, when examined by the microfcope, he difcovered them to be gills, through which the creatures refpire. Each gill confifts of a fhort trunk, and two large branches, or tubes, which give off on all fides a number of fmaller ramifications, and are perfectly fimilar to the tracheae of other infects. At the origin of every gill, two tracheae penetrate the trunk, and are difperfed through the body of the animal.

Though the ftigmata, or refpiratory organs, of caterpillars and other infects, were long known to ferve the purpofe of infpiration, yet it was uncertain whether the animals refpired by the fame orifices, till Bonnet, and, after him, Reaumur, afcertained the fact by many curious and accurate experiments. The firft of thefe authors immerfed numbers of caterpillars, of different kinds, and at different times, in water, and he obferved, both with the naked eye, and by the affiftance of a glafs, bubbles of air iffuing from various parts of their bodies, and particularly from the ftigmata. To remove all deception from his experiments, before immerfion, he carefully moiftened the caterpillars with water, in order to diflodge any portions of the external air that might be adhering to their bodies. Some of them he allowed to remain fo long under water, that they had every appearance of death. He then raifed the head and the two anterior ftigmata above the furface. The head, and firft pair of legs, foon began to move from fide to fide; and the body neceffarily partook of the fame motions. During thefe movements, many bubbles of air iffued from the pofterior and intermediate ftigmata, which ftill remained under water; but the membranous limbs continued nearly at reft. He next kept a caterpillar under water till all motion was fufpended. Then he elevated the anus and the two laft ftigmata above the furface, that they might have a communication with the external air. He kept the animal in this fituation about half an hour, without any fymptoms of re-animation. After raifing the body fucceffively from the laft to the firft pair of ftigmata, ftill the animal exhibited no fymptoms of life; but, when he expofed the

the whole body to the external air for half an hour, the powers of life completely returned. After ſuſpending the caterpillar about two hours with the laſt five pair of ſtigmata above the ſurface, he found that life was not extinguiſhed. He then raiſed the water till the anus and laſt pair of ſtigmata only were expoſed to the atmoſphere. He allowed the caterpillar to remain in this ſituation more than half an hour; and he obſerved that it often bended its body with a view to reach the ſurface, and that, during theſe efforts, bubbles of air iſſued from the anterior, but not from the poſterior ſtigmata. He likewiſe remarked, that, on the ſmalleſt motion of the animal, theſe bubbles were diſcharged, but that they were augmented both in quantity and ſize, in proportion to the agitations of the body. M. Bonnet immediately raiſed the water till it covered the two laſt ſtigmata; the caterpillar was violently agitated; but no bubbles of air, the communication being cut off, appeared, and all motion ceaſed. He inſtantly lowered the water, and expoſed the two poſterior ſtigmata to the air; the animal reſumed its movements; but in a moment after it expired. By another experiment, M. Bonnet diſcovered that a caterpillar lived eight days ſuſpended in water, during all which time it breathed ſolely by the two poſterior ſtigmata.

After theſe, and many other facts of a ſimilar kind, which demonſtrate that air is neceſſary for the ſupport and continuation of animal life, it ſhall only be remarked, that, when caterpillars undergo their laſt change, and appear in the form of flies of every denomination, Nature has ſtill furniſhed them with ſtigmata, or reſpiratory organs.

Reptiles of all kinds are likewiſe furniſhed with organs of reſpiration. Land-ſnails, at the approach of winter, bury themſelves in the earth, or retire into holes of rocks, or of old buildings, where they

they remain in a torpid ſtate during the ſeverity of the ſeaſon. For protection and warmth, theſe animals, when they go into their winter habitations, form, by means of a ſlime or ſaliva that iſſues from every pore of their bodies, a membranous cover which ſtops up the mouths of their ſhells. But this pellicle or cover, though apparently pretty hard and ſolid, is ſo thin and porous as not entirely to exclude the entrance of air, without which the principle of life could not be continued. Accordingly, when, by accident, the pellicle is made too thick, and prevents a communication with the external air, the animal, to remedy the evil, makes a ſmall aperture in its cover. In this ſtate ſnails remain ſix or ſeven months, without food or motion, till the genial warmth of the ſpring breaks their ſlumber, and calls forth their active powers. Hence it ſhould appear, that air is more neceſſary to the preſervation of animal life than food itſelf; for, in numberleſs inſtances, animals can live, not for days or weeks, but for months, without ſupplies of nouriſhment. None of them, however, are capable of exiſting nearly ſo long without having ſome communication with the air.

With regard to ſnails that live in freſh waters, or in the ocean, the ſpecies of which are numerous, their manner of reſpiring is ſingular. All of them have an aperture on the right ſide of the neck. This aperture ſerves the complicated purpoſes of diſcharging the faeces, of lodging the organs of generation, of aſcending and deſcending in the water, and of reſpiration. They are frequently obſerved to ſtraiten the orifice of this aperture, to ſtretch it out in the form of an oblong tube; and, in this ſtate, they riſe to the ſurface, in order to expel the former air, and take in a new ſupply.

But, though air ſeems to be an indiſpenſible principle of animal life, yet many animals can live longer without the uſe of this element, or at leaſt with ſmaller quantities of it, than others. Even men, by long practice, acquire the faculty of retaining the air in their lungs for an almoſt incredible length of time. Some of thoſe wretched creatures who are compelled by tyranny to dive for pearl-oyſters, have been known to continue under water three quarters of an hour without receiving a freſh ſupply of air. Thoſe animals which lie torpid during the winter, as the hedge-hog, the dormouſe, the marmot, &c. though perhaps not entirely deprived of all communication with the air, exiſt, without any apparent breathing, till the heat of the ſpring reſtores their wonted powers of life, when the reſpiration of air becomes again equally neceſſary as before their torpor commenced. The toad, like all the frog-kind, is torpid in winter. At the approach of winter, the toad retires to the hollow root of a tree, to the cleft of a rock, and ſometimes to the bottom of a ditch or pond, where it remains for months in a ſtate of ſeeming inſenſibility. In this laſt ſituation, it can have very little communication with the air. But ſtill the principle of life is continued, and the animal revives in the ſpring. What is more wonderful, toads have been found, in a hundred places of the globe, incloſed in the heart of ſolid rocks, and in the bodies of trees, where they have been ſuppoſed to exiſt for centuries, without any apparent acceſs either to nouriſhment or to air; and yet they were alive and vigorous. In the Memoirs of the Academy of Sciences for the year 1719, we have an account of a toad found alive, and healthy, in the heart of an old elm. Another, in the year 1731, was diſcovered, near Nantz, in the heart of an old oak, without any viſible entrance to its habitation. From the ſize of the tree, it was concluded, that the animal muſt have been confined in that ſituation at leaſt eighty or a hundred years. In the many examples of toads found in ſolid rocks, exact impreſſions of the animals bodies, correſponding to their reſpective ſizes, were uniformly left in the ſtones or trees from which they were diſlodged; and, to this day, it is ſaid, that there is a marble chimney-piece at Chatſworth with a print of a toad in it;

and a traditionary account of the place and manner in which it was difcovered.

Thefe, and fimilar facts, are fupported by authorities fo numerous and fo refpectable, that it is unneceffary to quote them. Many abortive attempts have been made to account for an animal's growing and living very long in the fituations above defcribed, without the poffibility of receiving nourifhment or air; efpecially as, like all other animals, when put into an exhaufted receiver, the toad foon lofes its exiftence. Upon this fubject I fhall only hazard two obfervations. The toad, it is well known, when kept in a damp place, can live feveral months without food of any kind, though, in its ftate of natural liberty, it devours voracioufly fpiders, maggots, ants, and other infects. Here we have an inftance, and there are many, of an animal whofe conftitution is fo framed by Nature, that it can exift feveral months without receiving any portion of food. According to our ideas of the neceffity of frequent fupplies of nourifhment, it is nearly as difficult for us to conceive an abftinence of four or fix months as one of as many years, or even centuries. The one fact, therefore, though we are unable to account for either, may be as readily admitted as the other. The fame remark is equally applicable to the regular refpiration of air. The toad, and many other animals, from fome peculiarity in their conftitution, can live very long in a torpid ftate without feeming to refpire, and yet their principle of life is not entirely extinguifhed. Hence the toad may, and actually does, live many years in fituations which exclude a free intercourfe with the external air. Befides, almoft all the above, and fimilar facts, muft, from their nature, have been difcovered by common labourers, who are totally unqualified for examining every circumftance with the difcerning eye of a philofopher. In rocks there are many chinks, as well as fiffures, both horizontal and perpendicular; and in old trees nothing is more frequent than holes and vacuities of different dimenfions.

ſions. Through theſe fiſſures and vacuities the eggs of toads may accidentally be conveyed by water, the penetration of which few ſubſtances are capable of reſiſting. After the eggs are hatched, the animals may receive moiſture, and ſmall portions of air, through the crevices of rocks, or the channels of aged trees. But I mean not to perſuade; for I cannot ſatisfy myſelf. All I intend is to recommend, to thoſe gentlemen who may hereafter chance to ſee ſuch rare phaenomena, a ſtrict examination of every circumſtance that can throw light upon a ſubject ſo dark and myſterious; for the vulgar, ever inclined to render uncommon appearances ſtill more marvellous, are not to be truſted.

From the facts I have enumerated, it is apparent that air, in certain proportions, according to the ſtructure and conſtitution of every animated being of which we have any knowledge, is indiſpenſibly neceſſary for the exiſtence and continuation of animal life. Not only men, quadrupeds, birds, fiſhes, reptiles, and the larger inſects, but even fleas, mites, the minute eels found in paſte or in vinegar, and the animalcules produced by infuſing animal or vegetable ſubſtances in water, inevitably periſh when deprived of this all-vivifying element.

With regard to plants, air is ſo neceſſary to their exiſtence, that they do not vegetate in an exhauſted receiver. Plants, as formerly mentioned, are furniſhed with numerous air-veſſels, or reſpiratory organs. They abſorb and tranſmit air through every pore. When placed in an exhauſted receiver, the air contained in every part of their ſubſtance is ſoon extracted; and, in proportion as this air is likewiſe pumped out by the machine, the flowers and leaves ſhow evident ſymptoms of debility; they become flaccid, pendulous, and aſſume a ſickly appearance; and, if retained in that ſituation a certain length of time, their vegetating powers are irrecoverably extinguiſhed.

Upon the whole, as the air we continually breathe is an univerſal menſtruum, and, of courſe, liable to be impregnated with exhalations from every ſubſtance to which it has acceſs, the great importance of perſonal, as well as of domeſtic cleanlineſs, is an obvious reflection. In building towns or houſes, the ſituation, with regard to air, is a capital object. The vicinity of marſhes, of ſtagnating waters, of manufactures of tallow, oil, ſal ammoniac, the ſmelting or corroding of metals of every kind, and many other operations which contaminate the air, ſhould be either avoided or removed, as they are the peſts of our ſenſes, and the poiſoners of our conſtitutions. Even in northern climates, houſes ſurrounded with trees, or in the neighbourhood of luxuriant vegetables, are always damp, and infeſted with inſects; and hence the ambient air is replete with the ſeeds of diſeaſe. Precautions of this kind are ſtill more neceſſary in hot climates. Air, like other menſtruums, abſorbs a greater or leſs proportion of the particles of bodies, according to its degree of heat. In Madrid, however, in Conſtantinople, and in many other cities of warm regions, the houſes are crouded together, the ſtreets are narrow, and covered with filth of every kind. We cannot, therefore, be ſurpriſed, that human beings exiſting in ſuch ſituations ſhould be ſo frequently infected with peſtilential diſeaſes.

CHAP.

CHAPTER IV.

Of Motion.

MOTION, in the opinion of Ariſtotle, and the admirers of ancient philoſophy, can only be produced by mind; and hence they define *mind* to be the *power of moving*. By the ſame mode of reaſoning, it may be ſaid that *reſt*, or *inactivity*, is the *power of being moved*. But ſuch ſpeculations are foreign to the nature of this work, and perhaps fruitleſs in themſelves. Though it is impoſſible to give an unexceptionable definition of motion, the phaenomenon itſelf is obvious to every man's ſenſes.

All the terreſtrial objects which preſent themſelves to our obſervation are, with regard to motion, diſtinguiſhable into two general claſſes. The firſt conſiſts of thoſe which are endowed with a ſpontaneous or ſelf-moving power, and with ſome qualities and affections ſimilar to thoſe of our minds. The ſecond conſiſts of all thoſe objects in which no ſuch qualities and affections appear, and are of a nature ſo paſſive, that they never move of themſelves, nor, when put in motion, do they ever ſtop without ſome external influence or reſiſtance. The firſt claſs of objects, from their poſſeſſing the power of ſpontaneous motion, and other qualities peculiar to animated beings, are eaſily diſtinguiſhed from body, or matter, which is totally deprived of all theſe qualities. In conſequence of its paſſive nature, matter not only never changes its ſtate without external force, but reſiſts when any ſuch change is attempted to be made. When at reſt, it cannot be put in motion without difficulty; and, when in motion, a certain force is required to ſtop its courſe. The force with which matter perſeveres in its ſtate, and reſiſts any change, is called its *vis inertiae*, and is always proportional to the quantity of matter in any particular body. When we double or triple a body, we uniformly find, that the force requiſite to move it with equal celerity muſt likewiſe be doubled or tripled. Theſe, and ſimilar facts, which are reſults of perpetual experience, ſhow that body is equally indifferent to motion and reſt; that this indifference ſeems to be the natural conſequence of the moſt abſolute inactivity; and that the power of beginning motion is peculiar to active and intelligent beings. Leaving, therefore, all metaphyſical ſpeculations on this ſubject, we ſhall give ſome remarks upon the motions of animals.

In general, all the progreſſive motions of animals are performed by the inſtrumentality of muſcles, tendons, and articulations. The operation of muſcles depends upon ſome unknown influence derived to them from the brain and nerves. Hence the brain and nerves are the ſources of every motion as well as of every ſenſation. With regard to the cauſes which determine the actions of animals, theſe muſt be referred to ſenſation, and the conſequent exertions of intellect. The firſt impreſſion an object makes upon our ſenſations ſtimulates us either to approach or retire from it, according as it excites affection or averſion. Theſe motions neceſſarily reſult from the firſt impreſſion made by the object. But man, and many other animals, have the power of reſiſting theſe original motives to action, and of remaining at reſt, without either retiring or approaching. 'If 'a man,' ſays the Count de Buffon, 'were deprived of ſight, he 'would make no movement to gratify his eyes. The ſame thing 'would happen, if he were deprived of any of the other ſenſes; 'and, if deprived of every ſenſe, he would remain perpetually at 'reſt, and no object would excite him to move, though, by natural 'conformation, he were fully capable of motion.' Natural wants, as that of taking nouriſhment, neceſſarily excite deſire or appetite. But, if a man be deprived of ſenſation, want cannot exiſt, becauſe all its ſources are annihilated. This is cutting off all the cauſes, and at the ſame time looking for the effects. An animal without ſome ſenſation is no animal, but a dead maſs of matter. Sentiment is the only ſtimulus to animal motion; the aptneſs of the parts produces the effect, which varies according to the ſtructure and deſtination of theſe parts. The ſenſe of want creates deſire. Whenever an animal perceives an object fitted to ſupply its wants, deſire is the neceſſary conſequence, and action or motion inſtantly ſucceeds.

Beſide progreſſive motion, the motion of hands, and other parts of animal bodies, which are all effected by means of muſcles, and are ſubject to the will of the creatures who perform them, there are other motions that have little or no dependence on our inclinations. Of this kind are the action of the heart, the circulation of the blood, the digeſtion of food, the periſtaltic motion of the bowels, the progreſs of the chyle from the ſtomach and inteſtines to the ſubclavian vein, the movement of the various ſecreted liquors, ſuch as the gall, the urine, the ſaliva, &c. Theſe, together with the action of the lungs in reſpiration, have received the denomination of *vital* and *involuntary motions*, becauſe moſt of them go on without any conſcious exertions of the intellectual principle. If ſuch a variety of nice and complicated movements had been left to the determination and direction of our minds, they muſt neceſſarily have occupied too much of our attention; and many of them would infallibly have been neglected.

glected during ſleep, when conſciouſneſs is often almoſt totally ſuſpended. But Nature in her operations is always wiſe. She has given to man, and other animals, the direction of no movements but what are eaſily performed, contribute to pleaſure and health, and enable them to acquire food correſponding to the ſtructure of their bodies and the elements in which they live.

It never was my intention, and, indeed, it would have been foreign to the deſign of this work, and ill ſuited to that claſs of mankind to whom I wiſh chiefly to be uſeful, to enter into the *rationale* of animal motion; to mention the number, inſertion, and direction, of the muſcles employed in moving the different parts of animated bodies; or to account for the modes by which animals walk, leap, fly, ſwim, creep, &c. Such diſcuſſions would not only require a volume, but a thorough acquaintance with all the depths of anatomical and mathematical knowledge. What follows, therefore, will conſiſt of ſome deſultory obſervations; and the ſubject ſhall be concluded by enumerating a few examples of movements peculiar to certain animals.

The motions of animals are proportioned to their weight and ſtructure. A flea can leap ſome hundred times its own length. Were an elephant, a camel, or a horſe, to leap in the ſame proportion, their weight would cruſh them to atoms. The ſame remark is applicable to ſpiders, worms, and other inſects. The ſoftneſs of their texture, and the comparative ſmallneſs of their ſpecific gravity, enable them to fall with impunity from heights that would prove fatal to larger and heavier animals.

Motion gives birth, perfection, death, and reproduction, to all animal and vegetable beings. It is the cauſe of all that diverſity and change which perpetually affect every object in the univerſe. The

The globe we inhabit, as well as the innumerable and ſtupendous heavenly bodies which preſent themſelves, in forms apparently minute to our obſervation, conſtantly exhibit motions of the moſt inconceivable rapidity. The magnitude of this earth, when conſidered with relation to man, and other animals, appears to be exceedingly great. It is indeed ſufficiently ſpacious, and ſufficiently prolific, for the conveniency and maintenance of its inhabitants. The magnificent objects diſplayed on its ſurface excite the admiration of every beholder. Its plains and mountains, its rivers and lakes, its iſlands and continents, its ſeas and oceans, continually ſollicit attention, gratify curioſity, and call forth the powers of reaſon and reflection. But, when compared to the other heavenly bodies, the number and magnitude of which exceed all the powers of human conception, the grandeur of our earth diminiſhes. Inſtead of exciting wonder, it almoſt vaniſhes from our ſight. Inſtead of an immenſe globe, it dwindles into a point, ſeems to occupy no ſpace, and loſes itſelf in the boundleſs regions of the univerſe. Conſiderations of this kind are apt to depreſs the dignity of man, and to leſſen his importance in the great ſcale of being; but they expand his mental faculties, and exalt his ideas concerning that inconceivable Power which firſt produced, and ſtill ſupports, thoſe aſtoniſhing orbs.

The different movements to which animals are ſtimulated by the deſire of food, by love, by the appetite for frolic and exerciſe, by their hoſtilities, and by other exciting cauſes, give animation and vivacity to the whole ſcene of nature. A ſilent and motionleſs proſpect, however beautiful and variegated, ſoon ceaſes to pleaſe, and at laſt becomes inſupportable. Motion, ſays Mr Harris, is the object or cauſe of all ſenſation. In muſic we hear it; in ſavours we taſte it; in odors we ſmell it; in touch we feel it; in light we ſee it.

Animals,

Animals furniſhed with deſtructive weapons, or endowed with uncommon ſtrength, courage, or ingenuity, are proportionally ſlower in their movements than the weaker kinds. The ſame remark is applicable to thoſe ſpecies whoſe food is always at hand. Worms, caterpillars, and many other inſects, in order to procure nouriſhment, are under no neceſſity of taking an extenſive range. But the motions of birds and fiſhes are extremely rapid; becauſe, in queſt of food, they are obliged to paſs through large tracks, and they have alſo many enemies to avoid.

Timid animals, as the hare, the rabbit, the Guiney-pig, &c. are almoſt perpetually in motion. Even when perfectly undiſturbed, they are reſtleſs, and betray a continual anxiety of danger. They run about, ſtop ſhort, erect their ears, and liſten. The Guiney-pig frequently raiſes itſelf on its hind-legs, and ſnuffs all around to catch the ſcent of food when hungry, or to increaſe its circle of hearing when afraid.

The movements of many animals are ſo extremely ſlow, that ſome of them, particularly thoſe of the ſhell tribes, are generally ſuppoſed to be deſtitute of the power of moving. It is a common notion, that both freſh and ſalt water muſcles have not the locomotive faculty. But this is a vulgar error. It is almoſt unneceſſary to mention, that the exterior part of muſcles conſiſts of two ſhells hinged together, which the animals can open or ſhut at pleaſure. Every perſon muſt likewiſe have obſerved, in the ſtructure of the animal itſelf, a fleſhy protuberance of a much redder colour, and denſer conſiſtence, than the other parts of the body. This muſcular protuberance, which conſiſts of two lobes, has been denominated a *trunk*, or *tongue:* But it is an inſtrument by which the creature is enabled to perform a progreſſive, though a very ſlow motion; and, therefore,

therefore, in defcribing its manner of moving, I fhall call thefe two lobes the animal's *tentacula*, or *feet*.

When inclined to remove from its prefent fituation, the river-mufcle opens its fhell, thrufts out its tentacula, and, while lying on its fide in an horizontal pofition, digs a fmall furrow in the fand. Into this furrow, by the operation of the fame tentacula, the animal makes the fhell fall, and thus brings it into a vertical pofition. We have now got our mufcle on end ; but how is he to proceed? He ftretches forward his tentacula, by which he throws back the fand, lengthens the furrow, and this fulcrum enables him to proceed on his journey.

With regard to marine mufcles, their progreffive motion is performed in the fame manner, and by the fame inftruments. When not in motion, they are all firmly attached to rocks, or fmall ftones, by many threads of about two inches in length, which ferve the double purpofes of an anchor and cable. Without this provifion of Nature, thefe animals muft become the fport of the waves, and the fpecies would foon be annihilated. But, how does the creature fpin thefe threads? A cylindrical canal extends from the origin to the extremity of the tentacula. In this canal an extremely glutinous fubftance is fecreted, which the animal, by the operation of certain mufcles, has the power of forcing out, and of attaching it, in the form of ftrong threads, to ftones or other folid bodies. More than a hundred and fifty of thefe cables are often employed in mooring a fingle mufcle *. The fubftance of the threads is exceedingly vifcous, indigeftible in the human ftomach, and is probably the caufe of thofe fatal confequences which fometimes happen to inattentive eaters. In Scotland, thefe threads are called the *beards* of

 mufcles,

* Oeuvres de Bonnet, tom. 5. pag. 361. 4to edit.

mufcles, and fhould be carefully pulled off before the animals are thrown into the ftomach.

Other bivalved fhell-fifhes, the fpecies of which are numerous, perform a progreffive or retrograde motion by an inftrument that has no fmall refemblance to a leg and foot. But the animals can, at pleafure, make this leg affume almoft every kind of form, according as their exigencies may require. By this leg they are not only enabled to creep, to fink into the mud, or difengage themfelves from it, but to perform a motion, which no man could fuppofe fhell-fifhes were capable of performing. When the tellina, or limpin, is about to make a fpring, it puts the fhell on the point or fummit, as if with a view to diminifh friction. It then ftretches out the leg as far as poffible, makes it embrace a portion of the fhell, and, by a fudden movement, fimilar to that of a fpring let loofe, it ftrikes the earth with its leg, and actually leaps to a confiderable diftance *.

The fpout-fifh † has a bivalved fhell, which refembles the handle of a razor. This animal is incapable of progreffive motion on the furface; but it digs a hole or cell in the fand, fometimes two feet in depth, in which it can afcend and defcend at pleafure. The inftrument or leg by which it performs all its movements is fituated at the centre. This leg is flefhy, cylindrical, and pretty long. When neceffary, the animal can make the termination of the leg affume the form of a ball. The fpout-fifh, when lying on the furface of the fand, and about to fink into it, extends its leg from the inferior end of the fhell, and makes the extremity of it take on the form of a fhovel, fharp on each fide, and terminating in a point. With this inftrument the animal cuts a hole in the fand. After the hole is made, it advances the leg ftill farther into the fand, makes it affume the

* Oeuvres de Bonnet, tom. 5. pag. 341. 4to edit.

† The name of the animal in Scotland. In England it is called *razor-fifh*.

the form of a hook, and with this hook, as a fulcrum, it obliges the ſhell to deſcend into the hole. In this manner the animal operates till the ſhell totally diſappears. When it chooſes to regain the ſurface, it puts the termination of the leg into the ſhape of a ball, and makes an effort to extend the whole leg; but the ball prevents any farther deſcent, and the muſcular effort neceſſarily puſhes the ſhell upward till it reaches the ſurface, or top of the hole. It is amazing with what dexterity and quickneſs theſe ſeemingly awkward motions are performed.

It is remarkable that the ſpout-fiſh, though it lives in ſalt water, abhors ſalt. When a little ſalt is thrown into the hole, the animal inſtantly quits his habitation. But it is ſtill more remarkable, that, if you ſeize the animal with your hand, and afterwards allow it to retire into its cell, you may ſtrew as much ſalt upon it as you pleaſe, but the fiſh will never again make its appearance. If you do not handle the animal, by applying ſalt, you may make it come to the ſurface as often as you incline; and fiſhermen often make uſe of this ſtratagem. This behaviour indicates more ſentiment and recollection than one ſhould naturally expect from a ſpout-fiſh.

The ſcallop, another well known bivalved ſhell-fiſh, has the power of progreſſive motion upon land, and likewiſe of ſwimming on the ſurface of the water. When this animal happens to be deſerted by the tide, it opens its ſhell to the full extent, then ſhuts it with a ſudden jerk, by which it often riſes five or ſix inches from the ground. In this manner it tumbles forward till it regains the water. When the ſea is calm, troops, or little fleets of ſcallops, are often obſerved ſwimming on the ſurface. They raiſe one valve of their ſhell above the ſurface, which becomes a kind of ſail, while the other remains under the water, and anſwers the purpoſe of an anchor, by ſteadying the animal, and preventing its being overſet. When an enemy approaches, they inſtantly ſhut their ſhells, plunge to the bottom, and the whole fleet diſappears. By what means they are enabled to regain the ſurface, we are ſtill ignorant.

With regard to the locomotive faculty of the oyſter, the following facts are recorded in the *Journal de Phyſique* by the Abbé Dicquemare. Like many other bivalved ſhell-fiſh, the oyſter has the power of ſquirting out water with a conſiderable force. By thus ſuddenly and forcibly ejecting a quantity of water, the animal repulſes ſuch enemies as endeavour to inſinuate into its ſhell while open. By the ſame operation, if not firmly attached to rocks, to ſtones, or to one another, the oyſter retreats backwards, or ſtarts to a ſide in a lateral direction. Any perſon may amuſe himſelf with the ſquirting and motions of oyſters, by putting them in a plate ſituated in a horizontal poſition, and which contains as much ſea-water as is ſufficient to cover them. The oyſter has been repreſented by many authors as an animal deſtitute not only of motion, but of every ſpecies of ſenſation. The Abbé Dicquemare, however, has ſhown, that it can perform movements perfectly conſonant to its wants, to the dangers it apprehends, and to the enemies by which it is attacked. Inſtead of being deſtitute of all ſenſation, oyſters are capable of deriving knowledge from experience. When removed from ſituations which are conſtantly covered with the ſea, devoid of experience, they open their ſhells, loſe their water, and die in a few days. But, even when taken from ſimilar ſituations, and laid down in places from which the ſea occaſionally retires, they feel the effects of the ſun's rays, or of the cold air, or perhaps apprehend the attacks of enemies, and accordingly learn to keep their ſhells cloſe till the tide returns. Conduct of this kind plainly indicates both ſenſation and a degree of intelligence.

The

The progreffive motion of the fea-urching, or fea-egg, a well known multivalved fhell-fifh, merits our attention. This animal, of which there are feveral fpecies, is round, oval, or fhaped like a bias-bowl. The furface of the fhell is divided into beautiful triangular compartments, and covered with numberlefs prickles; from which laft circumftance it has received the appellation of *fea-urchin*, or *fea-hedge-hog*. Thefe triangles are feparated by regular belts, and perforated by a great number of holes. Each hole gives lodgement to a flefhy horn fimilar to thofe of the fnail, and fufceptible of the fame movements. Like the fnail, the fea-urchin ufes its horns when in motion; but their principal ufe is to fix the animal to rocks, ftones, or the bottom of the ocean. By means of the horns and prickles, which proceed from almoft every point of the fhell, the fea-urchin is enabled to walk either on its back or on its belly. The limbs it moft generally employs are thofe which furround the mouth. But, when it choofes, it can move forward, by turning on itfelf like the wheel of a coach. Thus the fea-urchin furnifhes an example of an animal employing many thoufand limbs in its various movements. The reader may try to conceive the number of mufcles, of fibres, and of other apparatus, which are requifite to the progreffive motion of this little animal.

The motion of that fpecies of medufa, or fea-nettle, which attaches itfelf to rocks, and to the larger fhell-fifh, is extremely flow. The fea-nettles affume fuch a variety of figures, that it is impoffible to defcribe them under any determinate fhape. In general, their bodies have a refemblance to a truncated cone. The bafe of the cone is applied to the rock, or other fubftance to which they adhere. With regard to colour, fome of them are red, fome greenifh, fome whitifh, and others are brown. When the mouth, which is very large, is expanded, its margin is furrounded with a great number of flefhy filaments, or horns, fimilar to thofe of the fnail. Thefe horns

are

are difpofed in three rows around the mouth, and give the animal the appearance of a flower. Through each of thefe horns the fea-nettle fquirts water, like fo many jets-d'eau. What is peculiar in the ftructure of thefe creatures, the whole interior part of their body, or cone, is one cavity or ftomach. When fearching for food, they extend their filaments, and entangle any fmall animals they encounter. When they meet with their prey, they inftantly fwallow it, and fhut their mouths clofe like a purfe. Though the animal fhould not exceed an inch, or an inch and a half, in diameter, as it is all mouth and ftomach, it fwallows large whelks and mufcles. Thefe fhell-animals fometimes remain many days in the ftomach before they are ejected. Their nutrifying parts are at laft, however, extracted; but how does the fea-nettle get quit of the fhell? The creature has no other aperture in its body but the mouth, and this mouth is the inftrument by which it both receives nourifhment, and difcharges the excrement, or unprofitable part of its food. When the fhell is not too large, the fea-nettle has the power of turning its infide out, and by this ftrange maneouvre the fhell is thrown out of the body, and the animal refumes its former ftate. But, when the fhell prefents itfelf in a wrong pofition, the animal cannot difcharge it in the ufual manner; but, what is extremely fingular, near the bafe of the cone, the body of the creature fplits, as if a large wound had been made with a knife, and through this gafh the fhell of the mufcle, or other fhell, is ejected.

With regard to the progreffive motion of the fea-nettle, it is as flow as the hour-hand of a clock. The whole external part of its body is furnifhed with numerous mufcles. Thefe mufcles are tubular, and filled with a fluid, which makes them project in the form of prickles. By the inftrumentality of thefe mufcles, the animal is enabled to perform the very flow motion juft now mentioned. But this is not the only means by which the fea-nettle is capable of moving.

ving. When it pleafes, it can loofen the bafe of the cone by which it is attached to the rock, reverfe its body, and employ the filaments round its mouth as fo many limbs. Still, however, its movements are imperceptibly flow. For thefe facts feveral authors might be quoted; but we fhall refer the reader folely to M. de Bonnet *.

Before we conclude this chapter, we fhall juft mention a mode of flying which is peculiar to certain infects. The *mafon-bee*, which is one of the folitary fpecies, has received that appellation, becaufe it conftructs a neft with mud or mortar. Externally, this neft has no regular appearance; and is, therefore, generally regarded as a piece of dirt accidentally adhering to a wall. This habitation, however unfeemly in its exterior afpect, is furnifhed with regular cells, and often gives rife to great conflicts. When the real proprietor is abroad in queft of materials to finifh the neft, a ftranger takes pof-feffion. At meeting, a battle always enfues. This battle is fought in the air. Sometimes they fly with fuch rapidity and force againft each other, that both parties fall to the ground. But, in general, like birds of prey, the one endeavours to rife above the other, and to give a downward blow. To avoid the ftroke, the undermoft, inftead of flying forward or laterally, is frequently obferved to fly backward. This retrograde flight is likewife performed occafionally by the common houfe-fly, and fome other infects, though we are unable to perceive what ftimulates them to employ this uncommon movement.

* Oeuvres de Bonnet, 4to edit. tom. 5. pag. 345.

CHAPTER V.

Of the Inſtinct of Animals—Diviſion of Inſtincts—Examples of Pure Inſtinct—Of ſuch Inſtincts as can accommodate themſelves to peculiar circumſtances and ſituations—Of Inſtincts improveable by obſervation and experience—Some remarks and concluſions from this view of Inſtinct.

MANY theories have been invented with a view to explain the inſtinctive actions of animals; but none of them have received the general approbation of Philoſophers. This want of ſucceſs in the inveſtigation of a ſubject ſo curious and ſo intereſting muſt be owing to the operation of ſome powerful cauſes. Two of theſe cauſes appear to be a want of attention to the general oeconomy and manners of animals, and miſtaken notions concerning the dignity of human nature. From peruſing the compoſitions of moſt authors who have written upon animal inſtinct, it is evident, that they have chiefly derived their ideas, not from the various mental qualities diſcoverable in different ſpecies of animals, but from the feelings and propenſities of their own minds. Some of them, at the ſame time, are ſo averſe to allow brutes a participation of that intellect which man poſſeſſes in ſuch an eminent degree, that they conſider every animal action to be the reſult of pure mechaniſm.

chanifm. But the great fource of error on this fubject is the uniform attempt to diftinguifh inftinctive from rational motives. I fhall, however, endeavour to fhow that no fuch diftinction exifts, and that the reafoning faculty itfelf is a neceffary refult of inftinct.

The proper method of inveftigating fubjects of this kind, is to collect and arrange the facts which have been difcovered, and to confider whether thefe facts lead to any general conclufions. This method I have adopted; and fhall therefore exhibit examples of pure inftincts; of fuch inftincts as can accommodate themfelves to peculiar circumftances and fituations; and of inftincts improveable by obfervation and experience. In the laft place, I fhall draw fome conclufions.

I. *Of Pure Inftincts.*

By *pure* inftincts, I mean thofe, which, independent of all inftruction or experience, inftantaneoufly produce certain actions when particular objects are prefented to animals, or when they are influenced by peculiar feelings. Of this clafs the following are examples.

In the human fpecies, the inftinct of fucking is exerted immediately after birth. This inftinct is not excited by any fmell peculiar to the mother, to milk, or to any other fubftance; for infants fuck indifcriminately every thing brought into contact with their mouths. The defire of fucking, therefore, is innate, and coeval with the appetite for air.

The voiding of urine and excrement, fneezing, retraction of the mufcles upon the application of any painful ftimulus, the moving of the eye-lids, and other parts of the body, are likewife effects of original inftincts, and effential to the exiftence of young animals.

The love of light is exhibited by infants at a very early period. I have remarked evident fymptoms of this attachment on the third day after birth. When children are farther advanced, marks of the various paffions gradually appear. The paffion of fear is difcoverable at the age of two months. It is called forth by approaching the hand to the child's eye, and by any fudden motion or unufual noife. I once inftituted a courfe of experiments to afcertain the periods when the various paffions, principles, or propenfities, of the human mind are unfolded, and to mark the caufes which firft produced them. But, in lefs than five months after the birth of the child, the bufinefs became too complicated and extenfive for the time I had to beftow on fubjects of this nature.

The brute creation affords innumerable examples of pure inftincts.

When caterpillars are fhaken off a tree in every direction, all of them inftantly turn toward the trunk, and climb up, though they had never formerly been on the furface of the ground.

Young birds open their mouths upon hearing any kind of noife, as well as that of their mother's voice. They have no apprehenfions of harm; neither do they offer to ufe their wings till they acquire more ftrength and experience. The lion's cub is not ferocious till he feels force and activity for deftruction.

Infects invariably depofit their eggs in fituations moft favourable for hatching and affording nourifhment to their future progeny. Butterflies, and other infects, whofe offspring feed upon vegetables, uniformly

uniformly fix their eggs upon ſuch plants as are moſt agreeable to the palate and conſtitution of their young. Water inſects never depoſit their eggs on dry ground. I have ſeen butterflies which had been transformed in the houſe exhibit marks of the greateſt uneaſineſs becauſe they could not find a proper nidus for their eggs; and, when every other reſource failed, they paſted the eggs on the panes of the window.

Some ſpecies of animals look not to future wants. Others, as the bee and the beaver, are endowed with an inſtinct which has the appearance of foreſight. They conſtruct magazines, and fill them with proviſions.

The common bees attend the female, or queen, do her many little ſervices, and even feed her with honey from their trunks *. When deprived of the female, all their labours ceaſe †, till a new one is obtained, whom they treat with much reſpect, and renew their uſual operations ‡. They make cells of three different dimenſions, for holding workers, drones, and females; and the queen-bee, in depoſiting her eggs, diſtinguiſhes the three different kinds, and never puts a royal or a drone egg into the cells deſtined for the reception of the working bees. What is equally ſingular, the number of theſe cells is proportioned to that of the different bees to be produced. One royal cell weighs as much as one hundred of the common kind ‖. When there are ſeveral females in a hive, the bees work little till they have deſtroyed all the females but one. If more than a ſingle female were allowed to remain in a hive, a greater number of eggs would be laid than the working bees are able to make cells for receiving them.

* Reaumur, 12mo edit. vol. 9. pag. 300. † Ibid. pag. 320.
‡ Ibid. pag. 340. ‖ Ibid. tom. 10. pag. 124.

The wood-piercing bee, which is one of the ſolitary ſpecies, gnaws, with amazing dexterity and perſeverance, a large hole in old timber. After laying her eggs in the cells, ſhe depoſits ſuch a quantity of glutinous matter as nouriſhes the worms produced from theſe eggs till the time of their transformation into flies. She then paſtes up the mouth of the hole, and leaves her future offspring to the proviſion ſhe has made for them.

The bees of that ſpecies which build cylindrical neſts with roſe-leaves, exhibit a very peculiar inſtinct. They firſt dig a cylindrical hole in the earth. When that operation is finiſhed, they go in queſt of roſe-buſhes; and, after ſelecting leaves proper for their purpoſe, they cut oblong, curved, and even round pieces, exactly ſuited to form the different parts of the cylinder *.

The ſolitary waſp digs holes in the ſand. In each hole ſhe depoſits an egg. But how is the worm, after it is hatched, to be nouriſhed? Here the inſtinct of the mother merits attention. Though ſhe feeds not upon fleſh herſelf, and certainly knows not that an animal is to proceed from the egg, and far leſs that this animal muſt be nouriſhed with other animals, ſhe collects ten or twelve ſmall green worms, which ſhe piles one above another, rolls them up in a circular form, and fixes them in the hole in ſuch a manner that they cannot move. When the waſp-worm is hatched, it is amply ſtored with the food Nature has deſtined for its ſupport. The green worms are devoured in ſucceſſion †; and the number depoſited is exactly proportioned to the time neceſſary for the growth and transformation of the waſp-worm into a fly, when it iſſues from the hole, and is capable of procuring its own nouriſhment ‡.

There

* Reaumur, tom. 11. pag. 138.

† Ibid. tom. 12. pag. 18.

‡ Ibid. pag. 22.—32.

There are many other inftances of ichneumon wafps and flies, which, though they feed not themfelves upon worms, lay up provifions of thefe animals for the nourifhment of their young; and each kind is adapted to the conftitution of the worm that is to proceed from their eggs *.

Birds of the fame fpecies, unlefs when reftrained by peculiar circumftances, uniformly build their nefts of the fame materials, and in the fame form and fituation, though they inhabit very different climates. When removed by neceffity from their eggs, they haften back to them with anxiety. They turn and fhift their eggs, which has the effect of heating them equally. Ducks and geefe cover up their eggs till they return to the neft. A hen fits with equal ardour upon eggs of a different fpecies, or even upon artificial eggs. I have often contemplated with wonder an inftinct of the fwallow. When her offspring are very young, like other fmall birds, fhe carries their excrements out of the neft. But, after they are older, fhe attaches herfelf to the fide of the neft, and, by fome geftures and founds, follicits the young to void their excrements: One of them immediately turns round, elevates its hind parts above the edge of the neft, makes the proper effort, and the mother, before the dung is half protruded from the anus, lays hold of it with her bill, drags it out, carries it off, and drops it at a diftance from the neft. In all thefe operations, men recognife the intentions of Nature; but they are hid from the animals who perform them.

The fpider, the dermeftes, and many infects of the beetle kind, exhibit an inftinct of a very uncommon nature. When put in terror by a touch of the finger, the fpider runs off with great fwiftnefs: But, if he finds, that, whatever direction he takes, he is oppofed by another

* Reaumur, tom. II. pag. 38.

another finger, he then feems to defpair of being able to efcape, contracts his limbs and body, lies perfectly motionlefs, and counterfeits every fymptom of death. In this fituation I have pierced fpiders with pins, and torn them to pieces, without their difcovering the fmalleft mark of pain. This fimulation of death has been afcribed to a ftrong convulfion, or ftupor, occafioned by terror. But this folution of the phaenomenon is erroneous. I have repeatedly tried the experiment, and uniformly found, that, if the object of terror be removed, in a few feconds the animal runs off with great rapidity. Some beetles, when counterfeiting death, fuffer themfelves to be gradually roafted, without moving a fingle joint.

It is unneceffary to give more examples of pure inftincts. I fhall therefore proceed to the fecond clafs, namely,

II. *Of Inftincts which can accommodate themfelves to peculiar circumftances and fituations.*

To this clafs many human inftincts may be referred. But, as thefe inftinctive propenfities are likewife highly improveable by experience and obfervation, examples of them will fall more naturally to be given under the third clafs.

Thofe animals are moft perfect whofe fphere of knowledge extends to the greateft number of objects. When interrupted in their operations, they know how to refume their labours, and to accomplifh their purpofes by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, purfue their prey with intelligence and addrefs.

The

The oftrich has been accufed of unnaturalnefs, becaufe fhe leaves her eggs to be hatched by the heat of the fun. In Senegal, where the heat is great, fhe neglects her eggs during the day, but fits upon them in the night. At the Cape of Good Hope, however, where the degree of heat is lefs, the oftrich, like other birds, fits upon her eggs both day and night.

Rabbits dig holes in the ground for warmth and protection. But, after continuing long in a domeftic ftate, that refource being unneceffary, they feldom employ this art *.

Bees, when they have not room enough for their operations, augment the depth of their honey-cells †. The female bee, when the cells are not fufficiently numerous to receive her eggs, lays two or three in each cell. But, a few days after, when the cells are increafed, the working bees remove all the fupernumerary eggs, and depofit them in the new conftructed cells ‡.

When a wafp, in attempting to tranfport a dead companion from the neft, finds the load too heavy, he cuts off its head, and carries it out in two portions ||.

In countries infefted with monkeys, many birds, which, in other climates, build in bufhes and the clefts of trees, fufpend their nefts upon flender twigs, and, by this ingenious device, elude the rapacity of their enemies.

The nymphs of water-moths, commonly called *cod-bait*, cover themfelves, by means of gluten, with pieces of wood, ftraw, fmall fhells,

* Gazette Liter. tom. 3. pag. 228.
† Reaumur, tom. 10. pag. 29.
‡ Ibid. pag. 240.
|| Ibid. tom. 11. pag. 241.

ſhells, or gravel. It is neceſſary that they ſhould always be nearly in equilibrium with the water in which they live. To accompliſh this purpoſe, when their habitations are too heavy, they add a piece of wood, when too light a bit of gravel *.

I had a cat that frequented a cloſet, the door of which was faſtened by a common iron latch. A window was ſituated near the door. When the door was ſhut, the cat gave herſelf no uneaſineſs. As ſoon as ſhe tired of her confinement, ſhe mounted on the ſole of the window, and with her paw dexterouſly lifted the latch and came out. This practice ſhe continued for years.

Theſe examples, I hope, are ſufficient.

III. *The third claſs comprehends all thoſe Inſtincts which are improveable by experience and obſervation.*

The ſuperiority of man over the other animals ſeems to depend chiefly on the great number of inſtincts with which his mind is endowed. Traces of every inſtinct he poſſeſſes are diſcoverable in the brute creation. But no particular ſpecies enjoys the whole. On the contrary, moſt animals are limited to a ſmall number. This appears to be the reaſon why the inſtincts of brutes are ſtronger, and more ſteady in their operation, than thoſe of man. A being actuated by a great variety of motives muſt neceſſarily reaſon, or, in other words, heſitate in his choice. Its conduct, therefore, muſt often waver; and he will have the appearance of being inferior to another creature who is ſtimulated to action by a ſmaller number of motives. Man, accordingly, has been conſidered as the moſt vacillant

* Bonnet, tom. 4. pag. 209.——Reaumur, tom. 5. pag. 215.

lant and inconſiſtent of all animals. The remark is juſt; but, inſtead of a cenſure, it is an encomium on the ſpecies. The actions of a dog, or a monkey, for the ſame reaſon, are more various, whimſical, and uncertain, than thoſe of a ſheep or a cow.

Moſt human inſtincts receive improvement from experience and obſervation, and are capable of a thouſand modifications. This is another ſource of man's ſuperiority over the brutes. When we are ſtimulated by a particular inſtinct, inſtead of inſtantly obeying the impulſe, another inſtinct ariſes in oppoſition, creates heſitation, and often totally extinguiſhes the original motive to action. The inſtinct of fear is daily counteracted by ambition or reſentment; and, in ſome minds, fear is too powerful for reſentment, or any other inſtinct we poſſeſs. The inſtinct of anger is often reſtrained by the apprehenſion of danger, by the ſenſe of propriety, by contempt, and even by compaſſion. Sympathy, which is one of our moſt amiable inſtincts, frequently yields to anger, ambition, and other motives. The inſtinct or ſenſe of morality is too often thwarted by ambition, reſentment, love, fear, and ſeveral of what I call modified or compounded inſtincts, ſuch as avarice, envy, &c.

The following are examples of modified, compounded, or extended inſtincts.

Superſtition is the inſtinct of fear extended to imaginary objects of terror.

Devotion is an extenſion of the inſtinct of love to the Firſt Cauſe, or Author of the Univerſe.

Reverence or reſpect for eminent characters is a ſpecies of devotion.

Avarice is the inſtinct of love directed to an improper object.

Hope is the inſtinct of love directed to future good.

Envy is compounded of love, avarice, ambition, and fear.

Benevolence is the inſtinct of love diffuſed over all animated beings.

Sympathy is the inſtinct of fear transferred to another perſon, and reflected back upon ourſelves.

In this manner, all the modified, compounded, or extended paſſions and propenſities of the human mind, may be traced back to their original inſtincts.

The inſtincts of brutes are likewiſe improved by obſervation and experience. A young dog, like a child, requires both time and art to unfold and perfect his natural inſtincts. If neglected by man, he learns from his companions how to act in particular ſituations: But, when he enjoys both theſe ſources of information, his talents are improved to a degree that often excites our aſtoniſhment. The ſame remark applies to all docile animals, as the elephant, the horſe, the camel, &c. Every man's recollection will ſupply him with many examples of the improveable talents of brutes; and, therefore, it is unneceſſary to be more explicit.

Having exhibited inſtances of pure inſtinct, of inſtincts which accommodate themſelves to peculiar circumſtances and ſituations, and of inſtincts improveable by obſervation and experience, I ſhall now hazard a few remarks.

From

From the examples I have given, it appears that inftinct is an original quality of mind, which, in many animals, may be improved, modified, and extended, by experience; that fome inftincts are coeval with birth; and that others, as fear, anger, the principle of imitation, and the power of reafoning, or balancing motives, are gradually unfolded, according to the exigencies of the animal. One of the ftrongeft inftincts appears not till near the age of puberty; but, by bad example, and improper fituations, this inftinctive defire is often prematurely excited. The minds of brutes, as well as thofe of men, have original qualities, deftined for the prefervation of the individual and the continuation of the fpecies. The calling forth of thefe qualities is not inftinct, but the exertion or energy of inftinct. Inftincts exift before they act. What man or brutes learn by experince, though this experience be founded on inftinct, cannot with propriety be called inftinctive knowledge, but knowledge derived from experience and obfervation. Inftinct fhould be limited to fuch actions as every individual of a fpecies exerts without the aid either of experience or imitation. Hence inftinct may be defined, 'Every original quality of mind which produces particular 'feelings or actions, when the proper objects are prefented to it.' Thefe qualities or inftincts vary in particular fpecies. Some are endowed with many, and others with few. In fome they are ftronger, in others weaker; and their ftrength or weaknefs feems to be exactly proportioned to their number. The difference of talents among men who have had the fame culture, arifes from a bluntnefs, or abfolute deprivation, of fome original or modified inftincts. Tafte, or love of particular objects, whether animated, inanimated, or artificial, is in fome men fo obtufe, that we often fay it is entirely wanting. Infects have fewer inftincts than men or quadrupeds; but the exertions of infects are fo uniform and fteady, that they excite the admiration of every beholder.

Senſation implies a ſentient principle or mind. Whatever feels, therefore, is mind. Of courſe, the loweſt ſpecies of animals are endowed with mind: But the minds of animals have very different powers; and theſe powers are expreſſed by peculiar actions. The ſtructure of their bodies is uniformly adapted to the powers of their minds. We never ſee a mature animal attempting actions which Nature has not enabled it to perform, by beſtowing on it proper inſtruments. A bee collects the materials of honey and wax, but attempts not to gnaw rotten wood, like the waſp.—Neither does peculiarity of ſtructure prompt the actions of brutes. Calves puſh with their heads long before their horns are grown. This, and ſimilar examples, ſhew, that the inſtincts of brutes exiſt previous to the expanſion of thoſe inſtruments which Nature intended they ſhould employ.

This view of inſtinct is ſimple, removes every objection to the exiſtence of mind in brutes, and unfolds all their actions, by referring them to motives perfectly ſimilar to thoſe by which man is actuated. There is, perhaps, a greater difference between the mental powers of ſome animals than between thoſe of man and the moſt ſagacious brutes. Inſtincts may be conſidered as ſo many internal ſenſes, of which ſome animals have a greater, and others a ſmaller number. Theſe ſenſes, in different ſpecies, are likewiſe more or leſs ductile; and the animals poſſeſſing them are, of courſe, more or leſs ſuſceptible of improving, and of acquiring knowledge.

The notion that animals are machines, is perhaps too abſurd to merit refutation. Though no animal is endowed with mental powers equal to thoſe of man, yet there is not a faculty of the human mind, but evident marks of its exiſtence are to be found in particular animals. Senſes, memory, imagination, the principle of imitation, curioſity, cunning, ingenuity, devotion, or reſpect for ſuperiors,

ors, gratitude, are all difcoverable in the brute creation. Neither is art denied to them. They build in various ftyles; they dig; they wage war; they extract peculiar fubftances from water, from plants, from the earth; they modulate their voices fo as to communicate their wants, their fentiments, their pleafures and pains, their apprehenfions of danger, and their profpects of future good. Every fpecies has its own language, which is perfectly underftood by the individuals. They afk and give affiftance to each other. They fpeak of their neceffities; and this branch of their language is more or lefs extended, in proportion to the number of their wants. Geftures and inarticulate founds are the figns of their thoughts. It is neceffary that the fame fentiments fhould produce the fame founds and the fame movements; and, confequently, each individual of a fpecies muft have the fame organization. Birds and quadrupeds, accordingly, are incapable of holding difcourfe to each other, or communicating the ideas and feelings they poffefs in common. The language of gefture prepares for that of articulation; and fome animals are capable of acquiring a knowledge of articulate founds. They firft judge of our thoughts by our geftures; and afterwards acquire the habit of connecting thefe thoughts with the language in which we exprefs them. It is in this manner that the elephant and the dog learn to obey the commands of their mafters.

Infants are exactly in the fame condition with brutes. They underftand fome of our geftures and words long before they can articulate. They difcover their wants by geftures and inarticulate founds, the meaning of which the nurfe learns by experience. Different infants have different modes of expreffing their wants. This is the reafon why nurfes know the intentions of infants, though they are perfectly unintelligible to ftrangers. When an infant, accordingly, is transferred from one nurfe to another, the former in-

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ſtructs the latter in the geſtures and inarticulate language of the child.

The idea of a *machine* implies a ſelect combination of the common properties of matter. The regularity of its movements is a proof that they are totally diſtinct from animal or ſpontaneous motion. A machine has nothing analogous to ſenſation, which is the loweſt characteriſtic of an animal. An *animated machine*, therefore, is an abſurd abuſe of terms. It confounds what Nature has diſtinguiſhed in the moſt unambiguous manner. The inſtincts of brutes are, in general, ſtronger, and leſs ſubject to reſtraint, than thoſe of man. The reaſon is plain: They have not an equal number of inſtincts to curb, counterbalance, or moderate their motives to particular actions. Hence they have often the appearance of acting by mere impulſe; and this circumſtance has led ſome philoſophers to conſider brutes as machines. But they reflect not that children, ſavages, and ignorant men, act nearly in the ſame manner. It is ſociety and culture which ſoften and moderate the paſſions and actions of men, as well as thoſe of docile animals.

Brutes, like men, learn to ſee objects in their proper poſition, to judge of diſtances and heights, and of hurtful, pleaſureable, or indifferent bodies. Without ſome portion of reaſon, therefore, they could never acquire the faculty of making a proper uſe of their ſenſes. A dog, though preſſed with hunger, will not ſeize a piece of meat in preſence of his maſter, unleſs it be given to him: But, with his eyes, his movements, and his voice, he makes the moſt humble and expreſſive petition. If this balancing of motives be not reaſoning, I know not by what other name it can be called.

Animals, recently after birth, know not how to avoid danger. Neither can they make a proper uſe of their members. But experience

rience ſoon teaches them what is pleaſant and what is painful, what objects are hurtful and what ſalutary. A young cat, or a dog, who has had no experience of leaping from a height, will, without heſitation, precipitate itſelf from the top of a high wall. But, after perceiving that certain heights are hurtful, and others inoffenſive, the animal learns to make the diſtinction, and never afterwards can be prevailed upon to leap from a height which it knows will be productive of pain.

Young animals examine every object they meet with. In this inveſtigation they employ all their organs. The firſt periods of their life are dedicated to ſtudy. When they run about, and make frolickſome gambols, it is Nature ſporting with them for their inſtruction. In this manner they improve their faculties and organs, and acquire an intimate knowledge of the objects which ſurround them. Men who, from peculiar circumſtances, have been prevented from mingling with companions, and engaging in the different amuſements and exerciſes of youth, are always awkward in their movements, cannot uſe their organs with eaſe or dexterity, and often continue, during life, ignorant of the moſt common objects.

From the above facts and reaſoning, it ſeems to be apparent, that inſtincts are original qualities of mind; that every animal is poſſeſſed of ſome of theſe qualities; that the intelligence and reſources of animals are proportioned to the number of inſtincts with which their minds are endowed; that all animals are, in ſome meaſure, rational beings; and that the dignity and ſuperiority of the human intellect are neceſſary reſults, not of the conformation of our bodies, but of the great variety of inſtincts which Nature has been pleaſed to confer on the ſpecies.

CHAP.

CHAPTER VI.

Of the Senses.

NO animal of which we have any knowledge is endowed with more than the five external senses of smelling, tasting, hearing, touch, and seeing; and no animal, however imperfect, is destitute of the whole. Without organs of sensation, in a smaller or greater number, animal or intellectual existence is to us an inconceivable idea. Hence the notion of the ancients, and of a very few moderns, that this earth, as well as all the heavenly bodies, are intelligent beings, though they have not the vestige of any instrument of sensation, or of any thing analogous to our ideas of animation, except mechanical motion, is too absurd even to be seriously mentioned.

Upon this interesting subject, as it comprehends every source of information, and every motive to action in man, as well as in the inferior animals, it is not surprising that so much has been written, and that so many different theories have been invented, and submitted to public inspection. Some of these theories shall be taken notice of in a cursory manner, and others, as unworthy of attention, shall be passed over in silence.

Our

Our obſervations on the different inſtruments of ſenſation ſhall proceed in the following order, namely, of the ſenſes of ſmelling, of taſting, of hearing, of touch, and of ſeeing. In general, it may be remarked, that all ſenſation is conveyed to the mind by an unknown influence of the nerves. If the optic, olfactory, or any nerve diſtributed over an organ of ſenſation, be cut, or rendered paralytic, the animal inſtantly loſes that particular ſenſe. This is a fact univerſally eſtabliſhed by experiment. But that the nerves, which are perfectly ſimilar in every part of the body, ſhould, when diſtributed over the eye, the ear, the tongue, the noſe, convey to the mind feelings ſo different, is the moſt myſterious part of this ſubject. When M. de Bonnet tells us, that every organ of ſenſe probably conſiſts of fibres ſpecifically different; and that theſe fibres are particular ſenſes endowed with a peculiar manner of acting, correſponding to the perceptions they excite in the mind;—he means to reaſon; but he does no more than give a circumlocution for the fact.

OF SMELLING.

IN man, and many other animals, the organ by which the ſenſe of ſmelling is conveyed to the mind, has received the general appellation of *noſe*, or *noſtrils*. The more immediate inſtrument of this ſenſation is a ſoft, vaſcular, porous membrane, covered with numerous papillae, and is known by the name of *membrana pituitaria*, or *membrana Schneideriana*. This membrane is totally covered with infinite ramifications and convolutions of the olfactory nerves. Theſe nerves are almoſt naked, and expoſed to the action of the air which paſſes through the noſe in performing the function of reſpiration. But Nature, ever attentive to the eaſe and convenience of her creatures, has furniſhed the noſtrils with a number of glands, or ſmall arteries, which ſecrete a thick inſipid mucus. By this mucus, the olfactory nerves are defended from the action of the air, and from the painful ſtimuli of acrid odours.

The odours perceived by ſmelling are extremely various. Some of them convey to us the moſt delightful and refreſhing ſenſations, and others are painful, noxious, and diſguſting. All bodies in Nature, whether ſolid or fluid, whether animated or inanimated, continually ſend forth to the air certain effluvia or emanations from their reſpective ſubſtances. Theſe effluvia float in the atmoſphere, and act upon the olfactory nerves of different animals, and ſometimes of different individuals of the ſame ſpecies, in ſuch a manner as to produce very different ſenſations. What is pleaſant to the noſtrils of one animal is highly offenſive to thoſe of another. Brute animals ſelect their food chiefly by employing the ſenſe of ſmelling, and it ſeldom deceives them. They eaſily diſtinguiſh noxious from ſalutary food; and they carefully avoid the one, and uſe the other for nouriſhment. The ſame thing happens with regard to the drink of animals. A cow, when it can be obtained, always repairs to the cleareſt and freſheſt ſtreams; but a horſe, from ſome inſtinctive impulſe, uniformly raiſes the mud with his feet, and renders the water impure, before he drinks.

In the ſelection of food, men are greatly aſſiſted, even in the moſt luxurious ſtate of ſociety, by the ſenſe of ſmelling. By ſmelling we often reject food as noxious, and will not riſk the other teſt of taſting. Victuals which have a putrid ſmell, as equally offenſive to our noſtrils as hurtful to our conſtitutions, we avoid with abhorrence; but we are allured to eat ſubſtances which have a grateful and ſavoury odour. The more frequent and more acute diſcernment of brutes in the exerciſe of this ſenſe, is entirely owing to their freedom, and to their uſing natural productions alone. But men in ſociety, by the arts of cookery, by the unnatural aſſemblage of twenty ty ingredients in one diſh, blunt, corrupt, and deceive both their ſenſes of ſmelling and of taſting. Were we in the ſame natural condition as the brutes, our ſenſe of ſmelling would enable us to diſtinguiſh, with equal certainty, noxious from ſalutary food. Brutes, as well as men, prefer particular foods to others. This may be conſidered as a ſpecies of luxury; but it ſhould likewiſe be conſidered, that all the articles they uſe are either animal or vegetable ſubſtances in a natural ſtate, neither converted into a thouſand forms and qualities by the operation of fire and water, nor having their ſavour exalted by ſtimulating condiments. Domeſtic animals are nearly in the ſame condition with luxurious men. A pampered dog ſnuffs and rejects many kinds of food, which, in a natural ſtate, he would devour with eagerneſs.

It is not unworthy of remark, that, in all animals, the organs of ſmelling and of taſting are uniformly ſituated very near each other. Here the intention of Nature is evident. The vicinity of theſe two ſenſes forms a double guard in the ſelection of food. Were they placed in diſtant parts of the body, they could not ſo readily give mutual aid to one another.

But aſſiſtance in the choice of food is not the only advantage that men and other animals derive from the ſenſe of ſmelling. Every body in nature, whether animal, vegetable, or mineral, when expoſed to the air, continually ſends forth emanations, or effluvia, of ſuch extreme ſubtilty, that no eye can perceive them. Theſe effluvia, or volatile particles, diffuſe themſelves through the air, and moſt of them are recogniſed, by the organ of ſmelling, to be either agreeable or diſagreeable. To give ſome idea of the inconceivable minuteneſs of theſe particles, and of the amazing ſenſibility of the noſtrils of animals, the odour of muſk has been known to fill a large ſpace for ſeveral years without loſing any perceptible part of its weight. Thus, the air we breathe is perpetually impregnated with an infinity of different particles which ſtimulate the olfactory nerves, and give riſe to the ſenſation of ſmell. When our ſenſes are not vitiated by unnatural habits, they are not only faithful monitors of danger, but convey to us the moſt exquiſite pleaſures. Even the ſenſe of ſmelling is always productive either of pleaſure or pain. The fragrance of a roſe, and of many other flowers, is not only pleaſant, but gives a refreſhing and delightful ſtimulus to the whole ſyſtem, and may be conſidered as a ſpecies of wholeſome nouriſhment; while the odours proceeding from hemlock, and from many other noxious vegetable, animal, and mineral ſubſtances, are highly offenſive to our noſtrils. Hence we are naturally compelled to embrace the one claſs of ſenſations and to avoid the other.

Some animals, as the dog, the fox, the raven, &c. are endowed with a moſt exquiſite ſenſe of ſmelling. A dog ſcents various kinds of game at conſiderable diſtances; and, if the fact were not confirmed by daily experience, it could hardly gain credit, that he can trace the odour of his maſter's foot through all the winding ſtreets of a populous city. If we judge from our own feelings, this extreme ſenſibility in the noſe of a dog is to us perfectly incomprehenſible.

The ſenſe of ſmelling, like that of ſome other ſenſes, may be perverted or corrupted by habit. The ſnuffing, chewing, and ſmoking tobacco, though at firſt diſagreeable, become, by the power of habit, not only pleaſant, but almoſt indiſpenſible. The ſame remark is applicable to the practice of ſwallowing ardent ſpirits, the moſt deleterious of all poiſons, becauſe the moſt extenſively employed. How the natural ſtate of the nerves, and of the ſenſations conveyed by them, ſhould be ſo completely changed, we are totally ignorant. The conſtitution of the nerves often varies in different individuals of the ſame ſpecies. An odour which is diſguſtful to one man is

highly

highly grateful to another. I knew a gentleman who was in the daily habit of lighting and putting out candles, that he might enjoy the pleaſure of their ſmell. Few men, I ſuppoſe, would envy him.

OF TASTING.

THE tongue and palate are the great inſtruments of this ſenſation. With much wiſdom and propriety the organ of taſte is ſituated in ſuch a manner as enables it to be a guardian to the alimentary canal, and to aſſiſt the organ of ſmell in diſtinguiſhing ſalutary from noxious food. The tongue, like the other inſtruments of ſenſation, is amply ſupplied with nerves. The terminations of theſe nerves appear on the ſurface of the tongue in the form of *papillae*, or minute nipples, which are always erected on the application of ſapid or ſtimulating ſubſtances. This elevation and extenſion of the papillae, by bringing larger portions of the nerves into contact with the ſubſtances applied to the tongue, give additional ſtrength to the ſenſation, and enable us to judge with greater accuracy concerning their nature and qualities. Beſide the nervous papillae, the tongue is perpetually moiſtened with ſaliva, a liquor which, though inſipid itſelf, is one great cauſe of all taſtes. The ſaliva of animals is a very powerful ſolvent. Every ſubſtance applied to the tongue is partially diſſolved by the ſaliva before the ſenſation of taſte is excited. When the tongue is rendered dry by diſeaſe, or any other cauſe, the ſenſe of taſte is either vitiated or totally annihilated.

In ſome men, the ſenſe of taſte is ſo blunt, that they cannot diſtinguiſh with any degree of accuracy the different ſpecies of that ſenſation. In others, whether from Nature or from habit, this ſenſe is ſo acute, that they can perceive the niceſt diſtinctions in the ſavour of ſolids and of liquids.

The

The fenfations conveyed to the mind by tafte, like thofe of all the fenfes, are either agreeable, difagreeable, or indifferent. The pleafures arifing from this fenfe are not only great, but highly ufeful to every animal. The fenfe itfelf, however, is comparatively grofs; for, in fmelling, hearing, and feeing, fenfations are excited by emanations or undulations proceeding from bodies at great diftances from the animals who perceive them. But, in tafting, the object muft be brought into actual contact with the tongue before its qualities can be difcovered. How this proportionally grofs fenfe fhould have been felected, and figuratively applied to the general perception of every thing beautiful and fublime, whether in Nature or in art, it is difficult to determine. The inquiry, however, would not be incurious, whether men who have an obtufe fenfe of tafting material fubftances are likewife deficient in the perception of beauty and deformity.

Though the fenfe of tafte varies in fome individuals, yet, like figurative tafte, the ftandard of agreeable and difagreeable, of pleafant and painful, is almoft univerfally diffufed over mankind and the brute creation. Every horfe, and every ox, when in a natural ftate, eat and reject the fame fpecies of food. But men in fociety, as well as domeftic animals, are induced by habit, by neceffity, or by imitation, to acquire a tafte for many difhes, and combinations of fubftances, which, before the natural difcriminating fenfe is perverted, would be rejected with difguft.

Some individuals of the human fpecies have an averfion to particular kinds of food, which are generally agreeable. This averfion may be either original or acquired. I knew a child, who, from the moment he was weaned, could never be induced to take milk of any kind. Thefe original averfions muft be afcribed to fome peculiar modification in the ftructure of the organ, or in the difpofition

of

of its nerves. But, in general, difguft at particular foods is produced by furfeits, which injure the ftomach, and create, in that exquifitely irritable vifcus, an infuperable antipathy to receive nourifhment which formerly gave it fo much uneafinefs to digeft.

Brute animals, efpecially thofe which feed upon herbage, and are not liable to be corrupted by example or neceffity, diftinguifh taftes with wonderful accuracy. By the application of the tongue, they inftantly perceive whether any plant is falutary or noxious. To enable them, amidft a thoufand plants, to make this difcrimination, their nervous papillae, and their tongues, are proportionally much larger than thofe of man.

OF HEARING.

THE fenfation of hearing is conveyed to the mind by undulations of air ftriking the ear, an organ of a very delicate and complex ftructure. In man and quadrupeds, the external ears are large, and provided with mufcles by which they can erect and move them from fide to fide, in order to catch the undulations produced in the air by the vibrations of fonorous bodies, or to diftinguifh with greater accuracy the fpecies of found, and the nature and fituation of the animal or object from which it proceeds. Though the human ears, like thofe of quadrupeds, are furnifhed with mufcles, evidently intended for fimilar movements, yet, I know not for what reafon, there is not one man in a million who has the power of moving his ears. When we liften to a feeble found, we are confcious of an exertion; but that exertion, and the motions produced by it, are confined to the internal parts of the organ.

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The canals or paſſages to the internal parts of the ear are cylindrical, ſomewhat contorted, and become gradually ſmaller till they reach the *membrana tympani*, which covers what is called the drum of the ear. This membrane, which is extremely ſenſible, when acted upon by indulations of air, however excited, conveys, by means of a complex apparatus of bones, nerves, &c. the ſenſation of ſound to the brain or ſentient principle.

That air is the medium by which all ſounds are propagated, has been eſtabliſhed by repeated experiments. The ſound of a bell, ſuſpended in the receiver of an air-pump, gradually diminiſhes as the air is exhauſted, till it almoſt entirely ceaſes to be heard. On the other hand, when the quantity of air is increaſed by a condenſer, the intenſity of the ſound is proportionally augmented. Mr Haukſbee, in a paper publiſhed in the Philoſophical Tranſactions, has proved, that ſounds actually produced cannot be tranſmitted through a *vacuum*, or a ſpace deprived of air. 'I took,' ſays he, 'a ſtrong receiver, armed with a braſs hoop at the bottom, in which 'I included a bell as large as it could well contain. This receiver 'I ſcrewed ſtrongly down to a braſs plate with a wet leather be'tween, and it was full of common air, which could nowiſe make 'its eſcape. Thus ſecured, it was ſet on the pump, where it was 'covered with another large receiver. In this manner, the air con'tained between the outward and inward receivers was exhauſted. 'Now here I was ſure, when the clapper ſhould be made to ſtrike 'the bell, there would be actually ſound produced in the inward 'receiver; the air in which was of the ſame denſity as common air, 'could ſuffer no alteration by the *vacuum* on its outſide, ſo ſtrong'ly was it ſecured on all parts. Thus, all being ready for trial, the 'clapper was made to ſtrike the bell; but I found that there was no 'tranſmiſſion of it through the *vacuum*, though I was ſure there 'was actual ſound produced in the inward receiver.'

To enable us to underftand the manner in which founds are propagated through the air, philofophers have had recourfe to the undulations produced by a ftone thrown into a pond of ftagnating water. Thefe undulations affume the form of circular waves, which fucceffively proceed from the place where the ftone ftruck the water, as from a center, and continually dilate, and become greater and greater as they recede from that center, till they reach the banks of the water, where they either vanifh or are reflected. Now, as air is likewife a fluid, fimilar undulations, though to us invifible, are produced in it by the vibrations of fonorous bodies, and are alfo propagated to great diftances in fucceffive waves or rings. Thefe undulations of the air, when they come into contact with our organs of hearing, make fuch a tremulous impreffion upon them as excites in our minds the fenfation of found. This analogy, though not altogether perfect, is fufficient to illuftrate thofe invifible motions of the air by which founds are conveyed from one place to another, and to give an idea of echoes, or reflected undulations of that fluid.

The celerity with which founds, or undulations of air, move, has been exactly computed. All founds, whether acute or grave, ftrong or weak, move at the rate of 1142 feet in a fecond of time. Hence, whenever the lightning of thunder, or the fire of artillery, are feen, their actual diftances from the obferver may be eafily afcertained by the vibrations of a pendulum. This velocity, it is true, may be a little augmented or diminifhed by favourable or by contrary winds, and by heat or cold. But the difference, even in high winds, is fo trifling, that, for any ufeful purpofe, it fcarcely merits attention.

Infants hear bluntly, becaufe the bones of their ears are foft and cartilaginous; and, of courfe, the tremulations excited in them by the motions of the air are comparatively weak. Young children, accordingly, are extremely fond of noiſe. It rouſes their attention, and conveys to them the agreeable ſenſation of ſound; but feeble ſounds are not perceived, which gives infants, like deaf perſons, the appearance of inattention, or rather of ſtupidity.

The force or intenſity of ſound is augmented by reflection from ſurrounding bodies. It is from this cauſe that the human voice, or any other noiſe, is always weaker, and leſs diſtinctly heard, in the open air than in a houſe.

The modifications of ſound are not leſs various than thoſe of taſtes or odours. The ear is capable of diſtinguiſhing ſome hundred tones in ſound, and probably as many degrees of ſtrength in the ſame tones. By combining theſe, many thouſand ſimple ſounds, which differ either in tone or in ſtrength, are perceived and diſtinguiſhed by the ear. A violin, a flute, a French-horn, may each of them give the ſame tone; but the ear eaſily makes the diſtinction. The immenſe variety of ſenſations, ariſing from the organs of ſmelling, of taſting, and of hearing, enables animals to judge concerning the nature and ſituation of external objects. By habit we learn to know the bodies from which particular ſpecies of ſounds proceed. Previous to all experience, we could not diſtinguiſh whether a ſound came from the right or the left, from above or below, from a greater or a ſmaller diſtance, or whether it was the ſound of a coach, of a drum, of a bell, or of an animal. By catching cold, I once had a temporary deafneſs in my left ear. I was ſurpriſed to find that I had loſt the faculty of perceiving the ſituation from which ſounds proceeded. If a dog barked on the left, I thought the noiſe came from the right. This circumſtance excited my curioſity: But, upon recollection, I knew that my left ear was deaf; and that every ſound I heard was perceived ſolely by the right; and, conſequently, I diſcovered the cauſe of the deception.

Hearing

Hearing enables us to perceive all the agreeable ſenſations conveyed to our minds by the melody and harmony of ſounds. This, to man at leaſt, is a great ſource of pleaſure and of innocent amuſement. But ſome men are almoſt totally deſtitute of the faculty of diſtinguiſhing muſical ſounds, and of perceiving thoſe delightful and diverſified feelings excited by the various combinations of muſical tones. Moſt men derive pleaſure from particular ſpecies of muſic. But a muſical ear, in a reſtricted ſenſe, is by no means a general qualification. An ear for muſic, however, though not to be acquired by ſtudy, when the faculty itſelf is wanting, may be highly improved by habit and culture. Buffon, after examining a number of perſons who had no ear for muſic, ſays, that every one of them heard worſe in one ear than in the other; and aſcribes their inability of diſtinguiſhing muſical expreſſion to that defect. But a muſical ear ſeems to have no dependence on acuteneſs or bluntneſs of hearing, whether in one or in both ears. There are many examples of people who may be ſaid to be half deaf, and yet are both fond of muſic, and ſkilful practitioners. An ear for muſic, like a genius for painting or poetry, is a gift of Nature, and is born with the poſſeſſor.

Beſide the innumerable pleaſures we derive from muſic and agreeable ſounds, the extenſion and improvement of *artificial* language muſt be conſidered as objects of the greateſt importance to the human race. Without the ſenſe of hearing, mankind would forever have remained mute. I mention *artificial*, or improved language, becauſe, from a thouſand obſervations which every perſon muſt have made, it is perfectly apparent, that, if deſtitute of a *natural* language, neither man nor the brute creation * could poſſibly have exiſted and

* Concerning the language of beaſts, I ſhall, perhaps, be more explicit in a future work.

continued their ſpecies. As brutes, without information or experience, are capable of communicating to each other, by particular ſounds and geſtures, their pleaſures and pains, their wants and deſires, it would be the higheſt abſurdity to ſuppoſe that the great Creator ſhould have denied to man, the nobleſt animal that inhabits this globe, the ſame indiſpenſible privilege. Without a baſis there can be no fabric. Without a *natural* no *artificial* language could poſſibly have exiſted. This point is clearly demonſtrated, in a few words, by that moſt ingenious, candid, and profound philoſopher, Dr Thomas Reid, Profeſſor of Moral Philoſophy in the Univerſity of Glaſgow. 'If mankind,' ſays Dr Reid, 'had not a *natural* language, they could never have invented an artificial one by their 'reaſon and ingenuity. For all artificial language ſuppoſes ſome 'compact or agreement to affix a certain meaning to certain ſigns; 'therefore, there muſt be compacts or agreements before the uſe of 'artificial ſigns; but there can be no compact or agreement without 'ſigns, nor without language; and therefore there muſt be a natural language before any artificial language can be invented *.' Let any man try to overturn this argument, which is founded, not upon *metaphyſical* conjecture, but upon the ſolid baſis of *fact* and uncontrovertible *reaſoning*. The elements, or conſtituent parts of the natural language of mankind, the Doctor reduces to three kinds; modulations of the voice, geſtures, and features. 'By means of 'theſe,' ſays he, 'two ſavages, who have no common artificial language, can converſe together; can communicate their thoughts in 'ſome tollerable manner; can aſk and refuſe, affirm and deny, 'threaten and ſupplicate; can traffic, enter into covenants, and 'plight their faith.'

I

* Doctor Reid's Inquiry into the Human Mind, on the Principles of Common Senſe, pag. 93.

I can perceive only one plaufible objection to this reafoning. If, it may be faid, man were endowed with a natural language, this language muft be univerfal; from what fource, then, can the great diverfity of languages in different nations, and tribes of the human race, be derived? The folution of this queftion depends not upon metaphyfical arguments, but upon fact and experience. I have had confiderable opportunities of obferving the behaviour of children. Infants, when very young, have nearly the fame modes of expreffing their pleafures and pains, their defires and averfions. Thefe they communicate by voice, gefture, and feature; and every infant, whatever be the country, climate, or language, uniformly expreffes its feelings almoft in the fame manner. But, when they arrive at nine or twelve months of age, a different fcene is exhibited. They then, befide the general expreffions of feeling and defire, attempt to give names to particular objects. Here artifice begins. In thefe attempts, previous to the capacity of imitating articulate founds, every individual infant utters different founds, or rather gives different names, to fignify the fame objects of its defire or averfion. Befide this natural attempt towards a nomenclature, infants, during the period above mentioned, (for the time varies according to the health and vivacity of the child), frequently make continued orations. Thefe orations confift both of articulate and inarticulate founds, of which no man can give an idea in writing. But moft men, and every woman who has nurfed children, will perfectly underftand what I cannot exprefs. From the fact, that children actually utter different founds, or give different names to denote the fame objects, I imagine, arifes all that diverfity of languages, which, by exhaufting time and attention, retard the progrefs and improvement both of Art and Science. If any number of children, or of folitary favages, fhould chance to affociate, the names of objects would foon be fettled by imitation and confent. By obfervation and experience the number of names would be augmented, as well as the qualities or

attributes

attributes of the objects themfelves; and, in the progrefs of time, a new and artificial language would be gradually formed. While this operation is going on in one corner of a country, twenty fimilar affociations and compacts may be forming, or already formed, in different nations, or in different diftricts of the fame nation, all of which would give birth to feparate artificial languages.

OF TOUCH.

THE fenfations of fmelling, tafting, hearing, and feeing, are conveyed to us by partial organs, which are all confined to the head. But the fenfe of touching, or of feeling, is not only common to thefe organs, but extends over almoft every part of the body, whether external or internal. Though every fenfation may be comprehended under the general appellation of *feeling*, yet what is called the fenfe of *touch* is properly reftricted to the different fenfations excited by bodies applied to the fkin, and particularly to the tips of the fingers.

With regard to fenfation in general, it is worthy of remark, that the eyes, the ears, the noftrils, the tongue and palate, the palms of the hands, efpecially towards the points of the fingers, are more amply fupplied with nerves than any other external parts of the body. The terminations of the nerves on the furface of the fkin are foft and pulpy, and form minute protuberances refembling the nap of freeze-cloth, though greatly inferior in magnitude. Thefe protuberances have received the denomination of *nervous papillae*. They might be called *animal feelers*; for they are obvioufly the immediate inftruments of fenfation. If an object be prefented to the eye, or any other organ of fenfation, certain feelings are excited, which are either agreeable or difagreeable, according to the real or imaginary qualities which we confider as belonging to that object.

The

The feelings thus excited inſtantly produce a change in the ſenſitive organs by which they are occaſioned. If the object be poſſeſſed of diſagreeable qualities, averſion is the neceſſary conſequence. But, if beauty and utility are perceived in the object, pleaſant emotions ſpring up in the mind, which naturally induce a ſimilar tone or diſ-poſition in the organs ſuited for the enjoyment of theſe qualities.

When examining or enjoying any object, it is natural to inquire, what are the changes produced in the nervous papillae, or organs of ſenſation? If an object poſſeſſed of agreeable feelings is perceived, the nervous papillae inſtantly extend themſelves, and, from a ſtate of flaccidity, become comparatively rigid like briſtles. This exten-ſion of the papillae is not conjectural: It is founded on anatomical obſervation, and, in ſome caſes, may be ſeen and felt by perſons of acute and diſcerning ſenſations. When a man in the dark inclines to examine any ſubſtance, in order to diſcover its figure, or other qua-lities, he perceives a kind of rigidity at the tips of his fingers. If the fingers are kept long in this ſtate, the rigidity of the nervous papillae will give him a kind of pain or anxiety, which it is impoſ-ſible to deſcribe. The cauſe of this pain is an over-diſtenſion of the papillae. If a ſmall inſect creeps on a man's hand, when the papillae are flaccid, its movements are not perceived: But, if he hap-pens to direct his eye to the animal, he immediately extends his pa-pillae, and feels diſtinctly all its motions. If a body be preſent, which, in the common ſtate of the nerves, has ſcarcely any ſenſible odour, by extending the papillae of the noſtrils, an agreeable, diſa-greeable, or indifferent ſmell will be perceived. When two perſons are whiſpering, and we wiſh to know what is ſaid, we ſtretch the papillae, and the other organs of hearing, which are exceedingly complex. If a ſound is too low for making an impreſſion on the papillae in their natural ſtate of relaxation, we are apt to overſtretch the organ, which produces a painful or irkſome feeling. When we

examine

examine a mite, or any very minute object, by the naked eye, a pain is propagated over every part of that organ. Several causes may concur in producing this pain, such as the dilating of the pupil, and the adjusting the chrystalline lens; but the chief cause must be ascribed to the preternatural intumescence and extension of the papillae of the retina, the substance of which is a mere congeries of nervous terminations. This circumstance confirms a former remark, that the immediate organs of sensation were more copiously supplied with nervous papillae than those parts whose uses require not such exquisite sensibility; for a distinction in this respect is observable even among the sensitive organs themselves. They are furnished with nerves exactly proportioned to the subtility of the objects whose impressions they are fitted to receive. The eye possesses by far the greatest number. The particles of light are so minute, that, had not this wise provision been observed in the construction of the eye, it could never have been able to distinguish objects with such accuracy as at present it is capable of performing. When an insipid body, or a body which conveys but a very feeble sensation of taste, is applied to the tongue, we are conscious of an effort which that organ makes in order to discover the quality of the body thus applied. This effort is nothing but the stretching of the nervous papillae, that they may enlarge the field of contact with the body under examination.

The pleasure or pain produced by the sense of touch depends chiefly on the friction, or number of impulses, made upon the papillae. Embrace any agreeable body with your hand, and allow it to remain perfectly at rest, and you will find the pleasure not half so exquisite as when the hand is gently moved backward and forward upon the surface. Apply the hand to a piece of velvet, and it is merely agreeable: Rub the hand repeatedly on the surface of the cloth, and the pleasant feeling will be augmented in proportion to the

the number of impulſes on the papillae. When a man is pinched with hunger, the ſight or idea of palatable food raiſes the whole papillae of his tongue and ſtomach. From this circumſtance he is highly regaled by eating. But, if he eats the ſame ſpecies of food when his ſtomach is leſs keen, the pleaſure in the one caſe is not to be compared with what is felt in the other. The cauſe is obvious: His deſire was not ſo urgent; the object, of courſe, was leſs alluring; and therefore he was more remiſs in erecting his papillae, or in putting them in a tone ſuited to ſuch eminent gratification.

The ſame obſervations are applicable to diſagreeable or painful objects of contact. If the hand is laid upon a gritty ſtone, or a piece of ruſty iron, the feeling is diſagreeable; but if it is frequently rubbed upon the ſurface of theſe bodies, the feeling becomes inſufferably irkſome.

It is by the ſenſe of touch that men, and other animals, are enabled to perceive and determine many qualities of external bodies. By this ſenſe we acquire the ideas of hardneſs and ſoftneſs, of roughneſs and ſmoothneſs, of heat and cold, of preſſure and weight, of figure, and of diſtance. The ſenſe of touch is more uniform, and liable to fewer deceptions, than thoſe of ſmelling, taſting, hearing, and ſeeing; becauſe, in examining the qualities of objects, the bodies themſelves muſt be brought into actual contact with the organ, without the intervention of any medium, the variations of which might miſlead the judgment.

OF SEEING.

OF all the ſenſes, that of ſeeing is unqueſtionably the nobleſt, the moſt refined, and the moſt extenſive. The ear informs us of the existence of objects at comparatively small distances; and its information is often imperfect and fallacious. But the organ of sight, which is most admirably constructed, not only enables us to perceive thousands of objects at one glance, together with their various figures, colours, and apparent positions, but, even when unarmed, to form ideas of the sun and planets, and of many of the fixed stars; and thus connects us with bodies so remote, that imagination is lost when it attempts to form a conception of their immense magnitude and distances. This natural field of vision, however great, has been vastly extended by the invention of optical instruments. When aided by the telescope, the eye penetrates into regions of space, and perceives stars innumerable, which, without the assistance of art, would to us have no existence. Our ideas of the beauty, magnitude, and remoteness or vicinity of external objects, are chiefly derived from this delicate and acute instrument of sensation.

Before proceeding to the peculiarities of vision, and the general properties of light, we shall give a short description of the structure of the eye.

The globe of the eye is composed of three humours, called *aqueous*, *crystalline*, and *vitreous*; and of the *retina*, *ciliary ligament*, and *iris*. All these are contained within the *sclerotica* and *cornea*, or capsule of the eye. The white part of the cornea is opaque; but the *pupil*, or *sight* of the eye, through which the rays of light pass, is transparent. The *aqueous humour* is a *meniscus*, or a convex exteriorly, and concave internally. The *crystalline humour* is doubly convex; and its exterior convexity is embraced by the concave surface of the aqueous. The *vitreous* humour is likewise a meniscus; its concave surface embraces the interior convexity of the crystalline, and its convex surface is encompassed by the *retina*, which is a fine expansion of the medullary fibres of the optic nerve spread upon the

convex

convex ſurface of the vitreous humour, and covering the bottom of the eye. The *ciliary ligament* is a ring of fibres, which incloſe the edges of the cryſtalline, and ſtretch in right lines towards its center. When theſe fibres contract, the diſtance between the retina and cryſtalline is lengthened; and that diſtance is ſhortened when theſe fibres are in a relaxed ſtate. The *iris* is that coloured circle which ſurrounds the pupil.

By this curious apparatus all the phaenomena of viſion are conveyed to the mind. But, before we enter upon the manner in which the different parts of the eye concur in tranſmitting the rays of light and the images of objects to the retina, it will be neceſſary to give ſome general ideas concerning the nature of light, which is the univerſal medium of viſion.

Light conſiſts of innumerable rays, which proceed in direct lines from every part of luminous bodies. The motion of light, though not inſtantaneous, is inconceivably ſwift. To give ſome comparative idea of its great velocity, it has been diſcovered by philoſophers, that rays of light coming from the ſun reach this earth in ſeven minutes. Now, the diſtance of the earth from the ſun is ſo immenſe, that, ſuppoſing a cannon ball to move at the rate of 500 feet in a ſecond, it could not come from the ſun to the earth in leſs than 25 years. At this rate, the velocity of light will be above 10 million of times greater than that of a cannon ball.

The rays of light, though they proceed in direct lines from luminous bodies, are refracted, or bent out of their courſe, in paſſing through different mediums, as the air, glaſs, and every tranſparent ſubſtances; but, when they fall upon opaque bodies, they are reflected. Rays proceeding from any object, and paſſing through a convex glaſs or lens, are refracted and collected into a point, or ſmall ſpace, at a certain diſtance from the glaſs, which is called the *focus* of that lens.

The white light conveyed to us by the ſun is not homogeneous, but conſiſts of ſeven differently coloured rays, or what are called the *primary colours*. Theſe differently coloured rays were diſcovered by Sir Iſaac Newton to have different degrees of refrangibility. When the white light of the ſun was made to paſs through a glaſs priſm, he found, that, inſtead of retaining its original whiteneſs, it exhibited ſeven diſtinct colours, and that this phaenomenon was produced by the ſeveral rays in the compoſition of white light being more or leſs refracted, or turned from their direct courſe. The ſimple primary colours are ſeven in number, namely, red, orange, yellow, green, blue, indigo, and violet. Red is the leaſt, and violet the moſt refrangible parts of white light. A proper mixture of all the ſeven primary colours conſtitutes whiteneſs; and by various combinations of the primary colours, all the compound colours exhibited either in Nature or art are produced. Any ſurface appears black when it reflects little or no light.

The different humours of the eye, and the cryſtalline lens, are all denſer than air or water; of courſe, their power of refracting the rays of light is likewiſe greater. The rays proceeding from every point of an object enter the pupil; and the refraction of the different parts of the eye, which act as a lens, neceſſarily makes them croſs each other in their paſſage to the retina. After croſſing, they diverge till they are ſtopped by the retina, where they form an inverted picture. The upper part of the object is painted on the lower part of the retina, and the right ſide upon the left, &c. The celebrated Kepler firſt diſcovered, that diſtinct, but inverted pictures of every object we behold are painted on the retina by the rays of light proceeding from viſible objects. This diſcovery naturally led Kepler,

Kepler, as well as many other philofophers fince his time, to inquire how we fhould fee objects erect from inverted images on the retina.

Many ingenious theories have been invented, and many volumes have been written, in order to explain this feemingly difficult queftion. To give even a curfory view of thefe theories would not only be tedious, but in a great meafure ufelefs. We fhall therefore only remark, that their authors uniformly affumed it as a principle, that, becaufe the pictures are inverted on the retina, the mind ought alfo to perceive them in the fame pofition. It is certain, that, unlefs diftinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remotenefs, or any other caufe, a picture is indiftinctly painted on the retina, an obfcure or indiftinct idea of the object is conveyed to the mind. The picture on the retina, therefore, is fo far the caufe of vifion, that, unlefs this picture be clear and well defined, our ideas of the figure, colour, and other qualities of any object prefented to the eye, will be obfcure and imperfect. The retina of the eye refembles a canvas on which objects are painted. The colours of thefe pictures are bright or obfcure, in proportion to the diftances of the objects reprefented. When objects are very remote, their pictures on the retina are fo faint, that they are entirely obliterated by the vigorous and lively impreffions of nearer objects, with which we are every way furrounded. On the other hand, when near objects emit a feeble light only, compared with that which proceeds from a remote object, as, for example, when we view luminous bodies in the night, then very diftant objects make diftinct pictures on the retina, and become perfectly vifible. Hence a man, by placing himfelf in a dark fituation, and looking through a long tube, without the intervention of a glafs, may make a kind of telefcope, which will have a confiderable effect even during the day. For the fame reafon, a man at the bottom of a deep pit can fee the ftars at noon.

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The firſt and greateſt error in viſion, in the opinion of many authors, ariſes from the inverted repreſentation of objects upon the retina; and they maintain, that, till children learn the real poſition of bodies by the ſenſe of feeling, they ſee every object inverted. But new born animals, whether of the human or brute ſpecies, ſee objects, not inverted, but in their real poſitions, independently of all experience, or of any opportunity of rectifying the ſuppoſed illuſion by the ſenſe of touch. Animals ſee objects in their real poſition by a law of Nature, and by the inſtrumentality of the eye and optic nerve. Were it not a law of Nature, or of the conſtitution of animals, to ſee objects erect, though their images be inverted on the retina, an inverted object could not poſſibly appear inverted; for, in this caſe, we ſhould not be obliged to have recourſe to experience, or to the ſenſe of feeling. Beſides, it is an eſtabliſhed fact, that blind men, who had been reſtored to ſight by chirurgical operations, inſtantly ſaw objects in their real poſition *. There is no relation to the principles of optics, in the ſenſation of feeling, by which an image, painted by rays of light on ſoft white nervous terminations, is conveyed through a moſt opaque body, in a long courſe of perfect darkneſs, to the brain. Indeed, the ſenſe by which the perceiving nerves of any kind are affected, is not an image or idea of the object. The idea of redneſs has nothing in common with the leaſt refrangible portions of light ſeparated from the other ſix coloured rays of which white light is compoſed. The pain of burning repreſents not to the mind any thing of that ſwift and ſubtle matter by which the nervous threads are broken or deſtroyed. There is nothing in the idea of a ſharp ſound, from a cord of a certain length, which can inform the mind that this cord vibrates 2000 times in a ſecond †.

Another

* Haller. Phyſiol. tom. 2. pag. 87.

† For a more ample diſcuſſion of this point, ſee Haller. Phyſiol. tom. 2.;—and Dr Reid's Inquiry.

Another queſtion with regard to viſion has been much agitated by philoſophers. Becauſe a ſeparate image of every object is painted on the retina of each eye, it was concluded, that we naturally ſee all objects double; that we learn to correct this error of viſion by the ſenſe of touching; and that, if the ſenſe of ſeeing were not conſtantly rectified by that of touching, we ſhould be perpetually deceived as to the poſition, number, and ſituation of objects. The Count de Buffon mentions the real fact, though he aſcribes it to a wrong cauſe. 'When two images,' ſays he, 'fall on *correſponding* 'parts of the retinae, or thoſe parts which are always affected at the 'ſame time, objects appear ſingle, becauſe we are *accuſtomed* to judge 'of them in this manner. But, when the images of objects fall up- 'on parts of the retinae which are not uſually affected at the ſame 'time, they then appear double, becauſe we have not acquired the '*habit* of rectifying this unuſual ſenſation. Mr Cheſſelden, in his 'anatomy, relates the caſe of a man who had been affected with a 'ſtrabiſmus, or ſquinting, in conſequence of a blow on the head. 'This man ſaw every object double for a long time: But he gra- 'dually learned to correct this error of viſion, with regard to objects 'which were familiar to him; and, at laſt, he ſaw every object 'ſingle as formerly, though the ſquinting was never removed. This 'is a proof ſtill more direct, that we really ſee all objects double, 'and that it is by *habit* alone we learn to conceive them to be 'ſingle *.'

In this, and other paſſages, the Count de Buffon has pointed out the genuine cauſe (or ultimate fact) why we ſee objects ſingle with two eyes. He tells us, that, though a diſtinct image is painted on each retina, whenever theſe images are painted on correſponding points of the retinae, an object is perceived to be ſingle. It is equal-

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* Buffon, vol. 3. pag. 7. Tranſlat.

ly true, that, when one eye is diftorted by the finger, or any other caufe, in fuch a manner that the images are painted on points of the retinae which do not correfpond, the object is perceived to be double. Objects which are much nearer, or much more remote, than that to which both eyes are directed, appear double. If a candle is placed at the diftance of ten feet, and a man holds his finger at arm's-length between his eyes and the candle, when he looks at the candle, he fees his finger double, and, when he looks at his finger, he fees the candle double. 'In this phaenomenon,' Dr Reid properly remarks, 'it is evident to thofe who underftand 'optics, that the pictures of objects which are feen double, do not 'fall upon points of the retinae which are fimilarly fituated, but 'that the pictures of objects feen fingle do fall upon points fimilar-'ly fituated. Whence we infer, that as the points of the two reti-'nae, which are fimilarly fituated with regard to the centres, do 'correfpond, fo thofe which are diffimilarly fituated do not corre-'fpond. It is to be obferved, that although, in fuch cafes as are 'mentioned in the laft phaenomenon, we have been accuftomed 'from infancy to fee objects double which we know to be fingle; 'yet cuftom, and experience of the unity of the object, never take 'away this appearance of duplicity *.'

The fenfe of feeing, without the aid of experience, conveys no idea of diftance. If not affifted by the fenfe of touching, all objects would feem to be in contact with the eye itfelf. Objects appear larger or fmaller according as they approach or recede from the eye, or according to the angle they fubtend. A fly, when very near the eye, feems to be larger than a horfe or an ox at a diftance. Children can have no idea of the relative magnitude of objects, becaufe they have no notion of the different diftances at which they are feen. It

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* Dr Reid's Inquiry, &c. page 287.

is only after meafuring fpace by extending the hand, or by tranf-porting their bodies from one place to another, that children acquire juft ideas concerning the real diftances and magnitudes of objects. Their ideas of magnitude refult entirely from the angle formed by the extreme rays reflected from the fuperior and inferior parts of the object: Hence every near object muft appear to be large, and every diftant one fmall. But after, by touch, having acquired ideas of diftances, the judgment concerning magnitude begins to be recti-fied. If we judge folely by the eye, and have not acquired the ha-bit of confidering the fame objects to be equally large, though feen at different diftances, the neareft of two men, though of equal fize, would feem to be many times larger than the fartheft. But we know that the laft man is equally large with the firft; and, there-fore, we judge him to be of the fame dimenfions. Any diftance ceafes to be familiar to us, when the interval is vertical, inftead of being horizontal; becaufe all the experiments by which we ufually rectify the errors of vifion, with regard to diftances, are made hori-zontally. We have not the habit of judging concerning the mag-nitude of objects which are much elevated above or funk below us. This is the reafon that, when viewing men from the top of a tower, or when looking up to a globe or a cock on the top of a fteeple, we think thefe objects much fmaller than when feen at equal diftances in a horizontal direction. During the night, on account of the dark-nefs, we have no proper idea of diftance, and, of courfe, judge of the magnitude of objects folely by the largenefs of the angle or image formed in the eye, which neceffarily produces a variety of deceptions. When travelling in the night, we are liable to miftake a bufh that is near us for a tree at a diftance, or a diftant tree for a bufh which is at hand. When benighted in a part of the country with which we are unacquainted, and, of courfe, unable to judge of the diftance and figure of objects, we are every moment liable to all the deceptions of vifion. This is the origin of that dread which ſome men feel in the dark, and of thoſe ghoſts and horrible figures which ſo many people poſitively aſſert they have ſeen in the night. Such figures are commonly ſaid to exiſt in the imagination only; but they often have a real exiſtence in the eye; for, when we have no other mode of recogniſing unknown objects but by the angle they form in the eye, their magnitude is uniformly augmented in proportion to their vicinity. If an object, at the diſtance of twenty or thirty paces, appears to be only a few feet high, its height, when viewed within two or three feet of the eye, will ſeem to be many fathoms. Objects, in this ſituation, muſt excite terror and aſtoniſhment in the ſpectator, till he approaches and recogniſes them by actual feeling; for the moment a man examines an object properly, the gigantic figure it aſſumed in the eye inſtantly vaniſhes, and its apparent magnitude is reduced to its real dimenſions. But if, inſtead of approaching an object of this kind, the ſpectator flies from it, he retains the idea which the image of it formed in his eye, and he may affirm with truth, that he beheld an object terrible in its aſpect, and enormous in its ſize. Hence the notion of ſpectres, and of horrible figures, is founded in nature, and depends not ſolely on imagination.

When we have no idea of the diſtance of objects by a previous knowledge of the ſpace between them and the eye, we try to judge of their magnitudes by recogniſing their figures. But, when their figures are not diſtinguiſhable, we perceive thoſe which are moſt brilliant in colour to be neareſt, and thoſe that are moſt obſcure to be at the greateſt diſtance. From this mode of judging many deceptions originate. When a number of objects are placed in a right line, as lamps in a long ſtreet, we cannot judge of their proximity or remoteneſs but by the different quantities of light they tranſmit to the eye. Of courſe, if the lamps neareſt the eye happen to be more

more obſcure than thoſe which are more remote, the firſt will appear to be laſt, and the laſt firſt.

Before I diſmiſs this ſubject, I feel an irreſiſtible deſire of giving a ſhort view of the Abbé de Condillac's *Traité des Senſations* *; a moſt ingenious performance, which, I believe, is not very generally known in this country.

In an advertiſement prefixed to this Treatiſe, the ſagacious and learned Abbé deſires his readers to abſtract themſelves from all their preconceived opinions, and to imagine the ſituation and feelings of a ſtatue, limited, at firſt, to a ſingle ſenſe, and afterwards acquiring gradually the whole five.

1. *Senſe of Smelling alone.*

A man, or a ſtatue, who had no ſenſe but that of ſmelling, could have no other ideas than thoſe of odours. He would be the ſmell of a roſe, a violet, or a jeſſamine, according as the effluvia of theſe objects acted upon his ſingle organ of ſenſation. From agreeable or diſagreeable ſmells he would acquire ideas of pleaſure and pain. By means of agreeable and diſagreeable ſmells frequently repeated, theſe ſenſations would remain in his memory, and produce deſire and averſion. He can now compare the ſmell of a roſe with that of an

* From the edition 1754, in two volumes 12mo.

hemlock. As ſoon as he compares, he judges of the relation between two ideas. In proportion as theſe compariſons or judgments are repeated, he acquires, by habit, a greater facility in making them. He can judge of different degrees of pleaſure and pain. Hence, when he feels uneaſy, he recals pleaſant ſenſations which are paſt, and wiſhes for their return. This is the origin of deſire and want. Memory is the recollection only of what is paſt; but, when the ideas of objects preſent themſelves in ſo lively a manner, that he believes they are actually preſent, this operation of the mind is called imagination. Being limited to the uſe of one ſenſe, he would learn to diſtinguiſh ſmells with greater accuracy than beings endowed with more ſources of information. Abſtraction is the ſeparation of two ideas which have a natural connection. By reflecting that the ideas of pain and pleaſure reſult from different modifications of his exiſtence, he contracts the habit of ſeparating them, and thus acquires abſtract notions. To our ſtatue, a violet is a particular idea only; conſequently, all his abſtractions are limited to different degrees of pleaſure and pain. The ſucceſſion of ſenſations will give him ſome faint ideas of number, of paſt, and of future time. Duration is an idea purely relative, and changes according to the rapidity or ſlowneſs of our perceptions. Our ſtatue is incapable of diſtinguiſhing dreams, or a lively imagination, from real ſenſations. By the aid of memory he recogniſes his identity, and knows his preſent from his paſt condition. From theſe remarks it appears, that a man limited to one ſenſe is capable of acquiring the rudiments of every human faculty, and that theſe faculties are only extended by the addition of other ſenſes. Nearly the ſame acquiſitions would be made, if a man were limited to any of the other ſenſes.

2. *Of Hearing alone.*

The pleaſures of the ear ariſe chiefly from the ſucceſſion of ſounds conformably to the rules of melody or of harmony. Hence our ſtatue's deſires would not be confined to a ſingle ſound; he would wiſh to become a complete air. Sounds produce greater emotions than odours. They excite joy or ſadneſs independently of acquired ideas. Noiſe alone, without muſical expreſſion, would be agreeable: And muſic would convey pleaſure proportioned to the exerciſe of the ear. Simple, and even coarſe ſongs, would at firſt be raviſhing. But, when gradually accuſtomed to muſic more compounded, the ear would diſcover new ſources of delight. The pleaſure of a ſucceſſion of muſical tones being ſuperior to that of a continued noiſe, he would not confound the one with the other.

3. *Smelling and Hearing united.*

As theſe ſenſes, taken ſeparately, give to our ſtatue no idea of external objects, neither can they by their union. He would never ſuſpect that he had two different organs of perception, nor, at firſt, diſtinguiſh two modes of exiſtence in himſelf. Sounds and odours would be confounded, and ſeem to be only one ſimple modification. He would learn, however, by experience, and the aid of memory, to diſtinguiſh two ſenſations; and then he would think that his exiſtence was double. His train of ideas is more varied and extenſive, becauſe he has two kinds of modification; and, perhaps, noiſe would ſeem ſo different from harmonious ſounds, that he might imagine he had three ſenſes.

4. *Taste alone, and Taste united with* Smelling *and Hearing.*

When limited to tafte alone, the ftatue would acquire the fame mental powers as with fmelling or hearing. Tafte would contribute more to his happinefs and mifery than fmelling or hearing; becaufe favours, in general, affect us more than fmells, or even harmonious founds.

When tafte is united with fmelling and hearing, the ftatue, after learning to know them feparately, would be enabled to diftinguifh thefe fenfations, even when tranfmitted to him at the fame time; and therefore his exiftence would in fome meafure be tripled. The union of thefe fenfes would ftill farther extend and diverfify the train of his ideas, augment the number of his defires, and make him contract new habits.

5. *Of Sight alone.*

Sight and all fenfations are internal, and belong to the mind. The difficulty is to conceive how we refer thefe fenfations to external objects or caufes. Our ftatue would confider light and colour as modes of his own exiftence; but could have no idea that they belonged to bodies diftinct from himfelf. At firft he would not be able to diftinguifh one colour from another; but he would foon acquire the habit of confidering one colour at a time, and thus learn to diftinguifh them. By fight alone he could have no idea of figure, fituation, extenfion, or motion.

6. Sight

6. *Sight united with Smell, Hearing, and Taſte.*

This union would augment our ſtatue's mode of exiſtence, extend the chain of his ideas, and multiply the objects of his attention, of his deſires, and of his enjoyments. But he would ſtill continue to perceive himſelf alone, and could have no idea of external objects. He would ſee, ſmell, taſte, and hear, without knowing that he had eyes, noſe, mouth, or ears, nor even that he had a body. With the ſame colour before his eyes, if a ſucceſſion of ſmells, ſavours, and ſounds, were preſented to him, he would conſider himſelf as a colour ſucceſſively odoriferous, ſavoury, and ſonorous. If the ſame odour were conſtantly preſent with him, he would conſider himſelf as a ſavoury, ſonorous, and coloured odour.

7. *Of Touching alone.*

The ſmalleſt degree of ſentiment, or feeling, which a man limited to the ſenſe of touching could have, would ariſe from the action of different parts of the body, and particularly from the motion of reſpiration. This the Abbé calls the *fundamental ſentiment*, becauſe with it life commences. As ſoon as this fundamental ſentiment has undergone any change, the ſtatue is conſcious of his own exiſtence. When not ſtruck by any external body, and placed in a temperate tranquil air, of an equal degree of heat, he would only recogniſe his exiſtence by the confuſed impreſſion reſulting from the motion of reſpiration. He cannot diſtinguiſh the different parts of his body, and conſequently has no idea of extenſion. Different feelings perceived at the ſame time convey a confuſed ſenſation only. But, when heat and cold are felt in ſucceſſion, he diſtinguiſhes them, and retains

tains in his memory the idea of each ſenſation. Touching different parts of his body, and of external objects, gradually unfolds the ideas of extenſion, ſolidity, ſoftneſs, hardneſs, diſtance, &c. Hence he no longer confounds himſelf with his modifications. He is no longer heat or cold; but he perceives heat in one part and cold in another. By means of the hand, he diſtinguiſhes his own perſon from external objects. When he touches the parts of his body, each part returns a ſenſation. But, when he touches another body, he feels that it exiſts, but returns no ſenſation; and hence he learns that there are bodies which conſtitute no part of himſelf.

Children derive the greateſt happineſs from motion. Even falls do not deter them. A bandage on their eyes would give them leſs pain than a reſtraint on the uſe of their limbs. Motion, beſide many other advantages, gives them the moſt lively conſciouſneſs of their own exiſtence and powers. If exerciſe be pleaſant to children, it would be ſtill more ſo to our ſtatue; for as yet he not only knows no obſtacle to interrupt his movements, but he will ſoon experience all the pleaſures to be derived from motion. The ſtatue at firſt loves every body that does not hurt him. Poliſhed and ſmooth ſurfaces will be agreeable to him; and he will be delighted to find that he can at pleaſure enjoy warmth or coolneſs. He will receive peculiar pleaſure from objects, which, from their figure and magnitude, are moſt accommodated to the form of his hand. At other times, the difficulty of handling objects, on account of their ſize or weight, will give him pleaſure by ſurpriſe; and this pleaſure will be augmented by the ſpace he diſcovers around them, which will render the motion of his body from one place to another extremely agreeable. Solidity and fluidity, hardneſs and ſoftneſs, motion and reſt, will be pleaſant ſenſations; for the more he contraſts them, the more they will attract his attention and extend his ideas. But the habit he acquires of comparing and judging is the greateſt ſource of his pleafures. He no longer touches objects folely for the pleafure of handling them. He wifhes to know their relations, and he feels as many agreeable fenfations as he forms new ideas.

Touching expofes him more frequently to pain than the other fenfes. But pleafure is always within his reach, and pain is felt only at intervals. His defires confift chiefly of the efforts of his mind to recal the moft agreeable ideas. But that kind of defire of which the fenfe of touch renders him capable, includes motion, or the power of fearching for fenfations. Hence his enjoyments are not limited to the ideas prefented by the imagination, but extend to all the objects he can reach ; and his defires, inftead of being concentrated into modes of his exiftence, as in the other fenfes, lead him always to external bodies, which are the objects of his love, hatred, and other paffions.

By motion he acquires the idea of fpace. Repeated experience of difcovering new fenfations renders him capable of curiofity. But pain repreffes his defire of moving, and makes him diffident. Hence he learns to move with caution ; and the fame chance that led him to lay hold of a ftick, will teach him to ufe it for exploring what may be hurtful to him. Pleafure and pain are the fources of all his ideas, the number of which acquirable by our ftatue is almoft infinite. He learns to compare his different fenfations, and to diftinguifh different bodies. He acquires the idea of figure, and becomes capable of reflection and abftraction. He acquires likewife the ideas of number, of duration, of fpace, and of immenfity.

8. *Of Touch united with Smelling.*

On this ſuppoſition, the ſtatue would perceive himſelf to be two different beings, one that he could touch, and another which he could not. When chance made him lay hold of an odorous body, he would find that its ſmell was ſtronger or weaker, in proportion as he brought the body nearer, or removed it farther from his face. This experiment frequently repeated will give him the idea that ſmell proceeds from, or is a quality of bodies. By the ſame means he diſcovers the organ of ſmelling. From this ſource his ideas concerning the qualities of bodies are greatly extended.

9. *Hearing, Taſte, and Touching, united.*

At firſt our ſtatue is totally occupied with this new ſenſe, and believes himſelf to be the ſinging of birds, the noiſe of a caſcade, &c. By the exerciſe, however, of handling ſonorous bodies, or of letting them fall, he perceives that ſound is produced by impulſe or colliſion, gradually diſcovers this new organ, and that noiſe is a property of bodies even at a diſtance.

10. *Of Sight united with all the other Senſes.*

The eye conveys no idea of diſtance, of magnitude, of figure, or of ſituation, without the aſſiſtance of touching. Either from chance, or from the pain occaſioned by too ſtrong a light, the ſtatue carries his hand to his eyes. The colours of objects inſtantly diſappear. He removes his hand, and the colours return. Hence he learns that colours are not modes of his exiſtence, but that they ſeem to be ſomething exiſting in his eyes, in the ſame manner as he feels at the ends of his fingers the objects he touches.

The Abbé, in the ſame ingenious manner, ſhews how, by experience and habit, by motion and touching, we acquire a facility in correcting the errors of viſion. But our limits permit us not to follow him any farther.

CHAPTER VII.

Of Infancy.

BY the term *Infancy*, in this chapter, is generally meant that portion of life which commences at birth, and terminates at that period when animals have acquired the power of ſelf-preſervation, without any aſſiſtance from their parents. This period varies greatly in different animals. Of courſe, when different ſpecies are mentioned, the term *infancy* muſt have very different limitations with regard to time.

The ſtate of infancy, in the human ſpecies, continues longer than in any other animal. Infants, immediately after birth, are indeed extremely helpleſs, and require every aſſiſtance and attention from the mother. Moſt writers, however, on this ſubject ſeem to have exaggerated not only the imbecillity, but the miſeries of the infant ſtate. ‘ An infant,’ ſays Buffon, ‘ is *more helpleſs* than the young ‘ of any other animal: Its uncertain life ſeems every moment to vi- ‘ brate on the borders of death. It can neither move nor ſupport ‘ its body: It has hardly force enough to exiſt, and to announce, by ‘ groans, the pain which it ſuffers; as if Nature intended toappriſe ‘ the little innocent, that it is born to *miſery*, and that it is to be rank- ‘ ed among human creatures only to partake of their infirmities and ‘ of their afflictions *.’

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* Buffon, vol. 2. pag. 369. Tranſlat.

This humiliating picture is partly juſt, and partly miſrepreſented. Though infants remain longer in a ſtate of imbecillity than the young of other animals, they are by no means more *helpleſs*. The inſtant after birth, they are capable of ſucking whatever is preſented to their mouths. When in the ſame condition, the young of the opoſſum, of hares, rabbits, rats, mice, &c. can do no more. They can neither move nor ſupport their bodies. Beſides, many quadrupeds are deſtitute of the ſenſe of ſeeing for ſeveral days after birth. But the faculty of viſion is enjoyed by infants the moment after they come into the world. This faculty, in a few hours, becomes a great ſource of pleaſure and amuſement to them; but it is denied, for ſome days, to many other ſpecies of animals. The young of moſt birds are equally weak and helpleſs as human infants. The former have no other powers but thoſe of reſpiration, opening their mouths to receive food from the parent, and ejecting the excrement, after the food has been properly digeſted. If infants really ſuffer more pain and miſery than other animals in the ſame ſtate, Nature ſeems not to merit that ſeverity of cenſure which ſhe has ſometimes received. Man in ſociety, like domeſtic animals, by luxury, by artificial modes of living, by unnatural and vicious habits, debilitate their bodies, and tranſmit to their progeny the ſeeds of weakneſs and diſeaſe, the effects of which are not felt by thoſe who live more agreeably to the general oeconomy and intentions of Nature. The children of ſavages, for the ſame reaſon, whether in the hunting or ſhepherd ſtate, are more robuſt, more healthy, and liable to fewer diſeaſes, than thoſe produced by men in the more enlightened and refined ſtages of ſociety. Even under the ſame governments, and in the ſame ſtate of civilization, a ſimilar gradation of imbecillity and diſeaſe is to be obſerved. The children of men of rank and fortune are, in general, more puny, debilitated, and diſeaſed, than thoſe of the peaſant or artificer. Still, however, children, in their progreſs from birth to maturity, have innumerable ſources of pleaſure, which alleviate, if they

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do not fully compenfate, the pain which muft unavoidably be endured, whether in a more natural or more artificial ftate of mankind. If luxury and civilization debilitate the conftitutions of children, they give rife to many real enjoyments which are totally unknown to the favage. His wants are fewer; but his gratifications are more than proportionally diminifhed.

Though the period of human infancy be proportionally long, it is too often increafed by improper management. In this, and many other countries of Europe, infants have no fooner efcaped from the womb of their mothers, and have enjoyed the liberty of ftretching their limbs, than they are again condemned to a more cruel and unnatural bondage. The head is fixed in one pofition; the legs are fettered; the arms are bound down to the fides; and the little innocents are laced with bandages fo ftrait that they cannot move a fingle joint. The reftraint of fwaddling bands muft be productive of pain. Their original intention was to prevent the head and limbs from being diftorted by unnatural or hurtful pofitions. But it was not confidered, that the efforts made by infants to difentangle themfelves, have a greater tendency to diftort their members than any poftures they could affume, if they enjoyed a greater degree of liberty. But, if the efforts for liberty made by infants fettered in this cruel manner be hurtful, the ftate of inactivity in which they are forced to remain, is, perhaps, equally noxious. Infants, as well as all young animals, are extremely prone to motion. It promotes the growth and expanfion of their organs. It likewife invigorates all their members, and facilitates the circulation and fecretion of their different fluids. But, when infants are deprived of exercife, or of the power of performing their natural movements, the oppofite effects are produced. The want of exercife retards their growth and weakens their conftitution. Thofe children, therefore, who are allowed full freedom of motion will always be the moft healthy and the moft vigorous.

gorous. We are, however, happy to remark, that, by the efforts of philofophers and phyficians, the practice of employing tight bandages has of late become lefs general, efpecially among intelligent midwives and mothers. But, to eradicate long eftablifhed prejudices, and to diffufe more enlightened and falutary notions through a whole country, cannot be effected without a great length of time and vigorous exertions.

From what caufes or circumftances particular modes in the management of infants originate, it is difficult to determine. But it is certain that favages, and the ruder nations, in their treatment of infants, often difcover more difcernment, and propriety of conduct, than are to be found in the moft polifhed ftages of fociety. The negroes, the favages of Canada, of Virginia, of Brafil, and the natives of almoft the whole of South America, inftead of ufing fwaddling-bands, lay their infants naked into hammocks, or hanging beds of cotton, or into cradles lined with fur. The Peruvians leave the arms of their infants perfectly loofe in a kind of fwathing-bag. When a little older, they are put, up to the middle, in a hole dug out of the earth, and lined with linen or cotton. By this contrivance, their arms and head are perfectly free, and they can bend their bodies, and move their arms and head, without the fmalleft danger of falling, or of receiving any injury. To entice them to walk, whenever they are able to ftep, the breaft is prefented to them at a little diftance. The children of negroes, when very young, cling round, with their knees and legs, one of their mother's haunches, and grafp the breaft with their hands. In this pofition they adhere fo firmly, that they fupport themfelves without any affiftance, and continue to fuck without danger of falling, though the mother moves forward, or works at her ufual labour. Thefe children, at the end of the fecond month, begin to creep on their hands and knees; and, in this fituation, they acquire, by habit, the faculty of running with furprifing quicknefs.

Savages

Savages are remarkably attentive to the cleanlinefs of their children. Though they cannot afford to change their furs fo frequently as we do our linen, this defect they fupply by other fubftances of no value. The favages of North America put wood-duft, obtained from decayed trees, into the bottom of the cradle, and renew it as often as it is neceffary. Upon this powder the children are laid, and covered with fkins. This powder is very foft, and quickly abforbs moifture of every kind. The children in Virginia are placed naked upon a board covered with cotton, and furnifhed with a proper hole for tranfmitting the excrement. This practice is likewife almoft general in the eaftern parts of Europe, and particularly in Turkey. It has another advantage: It prevents the difmal effects which too often proceed from the negligence of nurfes.

Many northern nations plunge their infants, immediately after birth, into cold water, without receiving any injury. The Laplanders expofe their new-born infants on the fnow till they are almoft dead with cold, and then throw them into a warm bath. During the firft year, this feemingly harfh treatment is repeated three times every day. After that period, the children are bathed in cold water thrice every week. It is a general opinion in northern regions, that cold bathing renders men more healthy and robuft; and hence they inure their children, from their very birth, to this habit. In the ifthmus of America, the inhabitants, even when covered with fweat, plunge themfelves with impunity into cold water. The mothers bathe in cold water, along with their infants, the moment after delivery; yet much fewer of them die of child-bearing, than in nations where a practice of this kind would be confidered as extremely hazardous.

With regard to the food of infants, it fhould confift, for the firft two months, of the mother's milk alone. A child may be injured by by allowing it any other nourifhment before the end of the firft month. In Holland, in Italy, in Turkey, and over the whole Levant, children, during the firft year, are not permitted to tafte any other food. The Canadian favages nurfe their children four or five years, and fometimes fix or feven. In cafes of neceffity, the milk of quadrupeds may fupply that of the mother. But, in fuch cafes, the child fhould be obliged to fuck the animal's teat; for the degree of heat is always uniform and proper, and the milk, by the action of the mufcles, is mixed with the faliva, which is a great promoter of digeftion. Several robuft peafants have been known to have had no other nurfes than ewes. After two or three months, children may be gradually accuftomed to food fomewhat more folid than milk. Before the teeth fhoot through the gums, infants are incapable of maftication. During that period, therefore, it is obvious that Nature intended they fhould be nourifhed folely by foft fubftances. But, after they are furnifhed with teeth, it is equally obvious, that they fhould occafionally be allowed food of a more folid texture.

The bodies of infants, though extremely delicate, are lefs affected by cold than at any other period of life. This effect may be produced by the fuperior quicknefs in the pulfation of the heart and arteries which takes place in fmall animals. The pulfe of an infant is more frequent than that of an adult. The pulfe of a horfe, or of an ox, is much flower than that of a man; and the motion of the heart, in very fmall animals, as that of a linnet, is fo rapid that it is impoffible to count the ftrokes.

The lives of children, during the firft three or four years, are extremely precarious. After that period, their exiftence becomes gradually more certain. According to Simpfon's tables of the degrees of mortality at different ages, it appears, that, of a certain number of infants brought forth at the fame time, more than a fourth part of them died in the firſt year, more than a third in two years, and at leaſt one half at the end of the third year. Mr Simpſon made this experiment upon children born in London. But the mortality of children is not nearly ſo great in every place; for M. Dupré de S. Maur, by a number of experiments made in France, has ſhown, that one half of the children born at the ſame time are not extinct in leſs than ſeven or eight years.

To treat of the diſeaſes of children, or to enter minutely into the cauſes which contribute to the great mortality of mankind in early infancy, is no part of our plan. In general, theſe cauſes are to be referred to unnatural practices in the management of children, introduced by ſuperſtition, by ignorance, and by fooliſh notions ariſing from over-refinement, from prejudice, and from hypothetical ſyſtems, while the oeconomy and analogy of Nature, in the conduct and ſituation of the inferior animals, are almoſt totally neglected. Every animal, except the human ſpecies, brings forth its young without any foreign aid. But incredible numbers of children, as well as of mothers, are daily maimed, enfeebled, and deſtroyed, by the ignorance and barbarity of midwives and accoucheurs. An infant is no ſooner brought into the world than it is crammed with phyſic. Nature's medicine for cleanſing the bowels of infants is the milk of the mother. But midwives abſurdly imagine that drugs will anſwer this purpoſe much better. All other animals that give ſuck nurſe their own offspring: But we too frequently delegate this tender and endearing office to ſtrange women, whoſe conſtitutions, habits of life, and mental diſpoſitions, are often totally different from thoſe of the genuine parent. Infants, recently after birth, frequently ſuffer from giving them, inſtead of the mother's milk, wine-whey, water-gruel, and ſimilar unnatural kinds of nouriſhment. In this period of their exiſtence, however, very little food, but a great deal of reſt, is neceſſary for promoting their health, and ſecuring their eaſe and tranquillity;

tranquillity; for infants, when not teazed by officious cares, ſleep almoſt continually during ſeveral weeks after birth. Young animals are naturally fond of being in the open air; but our infants, particularly in large towns, are almoſt perpetually ſhut up in warm apartments, which both relaxes their bodies and enervates their minds. The great agility, ſtrength, and fine proportions of ſavages, are reſults of a hardy education, of living much in the open air, and of an unreſtrained uſe of all their organs the moment after they come into the world.

In young animals, as well as in infants, there is a gradual progreſs, both in bodily and mental powers, from birth to maturity. Theſe powers are unfolded ſooner or later, according to the nature and exigencies of particular ſpecies. This progreſs, in man, is very ſlow. Man acquires not his full ſtature and ſtrength of body till ſeveral years after the age of puberty: And, with regard to his mind, his judgement and other faculties cannot be ſaid to be perfectly ripe before his thirtieth year.

In early infancy, though the impreſſions received from new objects muſt be ſtrong, the memory appears to be weak. Many cauſes may concur in producing this effect. In this period of our exiſtence, almoſt every object is new, and, of courſe, ingroſſes the whole attention. Hence the idea of any particular object is obliterated by the quick ſucceſſion and novelty of others, joined to the force with which they act upon the mind. Haller aſcribes this want of recollection to a weakneſs of memory; but it ſeems rather to proceed from a confuſion which neceſſarily reſults from the number and ſtrong impreſſions of new objects. The memory ripens not ſo much by a gradual increaſe in the ſtrength of that faculty, as by a diminution in the number and novelty of the objects which ſollicit attention. In a few years children are enabled to expreſs all their wants and desires. The number of new objects daily diminishes, and the impressions made by those with which they are familiar become comparatively small and uninteresting. Hence their habits of attention, and the ardour of their minds, begin to relax. Instead of a general and undistinguishing gratification of their senses, this is the period when it is necessary to stimulate children, by various artifices, to apply their minds steadily to the examination of particular objects, and to the acquisition of new ideas from more complicated and refined sources of information. The great basis of education is a habit of attention. When this important point is gained, the minds of children may be molded into any form. But that restlessness, and appetite for motion, which Nature, for the wisest purposes, has implanted in the constitution of all young animals, should not be too severely checked. Health and vigour of body are the surest foundations of strength and improvement of mind.

With regard to the duration of infancy, from man to the insect tribes, it seems, in general, to be proportioned, not to the extent of life, but to the sagacity or mental powers of the different classes of animated beings. The elephant requires 30 years, and the rhinoceros 20, before they come to perfect maturity, and are enabled to multiply their species. But these years mark not the period of infancy; for the animals, in a much shorter time, are capable of procuring their own food, and are totally independent of any aid from their parents. The same remark is applicable to the camel, the horse, the larger apes, &c. Their ages of puberty are four, two and a half, and three years. But, in these quadrupeds, the terminations of infancy are much more early. The smaller quadrupeds, as hares, rats, mice, &c. are mature at the end of the first year after birth; and the Guiney pig and rabbit require only five or six months. There is a gradation of mental powers, though not without exceptions, from the larger to the more minute quadrupeds; for the dog and fox, whose whofe fagacity is very great, come to maturity in one year, and their ftate of infancy is fhort. But, of all animals, the infancy and helplefs condition of men are the moft prolonged; and the fuperiority and ductility of his mind will not be queftioned.

The infant ftate of birds is very fhort. Moft of the feathered tribes arrive at perfection in lefs than fix months; and their fagacity is comparatively limited.

With regard to fifhes, if the whale and feal kind, who fuckle their young, be excepted, they receive no aid from their parents. Fifhes no fooner efcape from the eggs of their mother, than they are in a condition to procure nourifhment, and to provide, in fome meafure, for their own fafety. Of the fagacity of fifhes, owing to the element in which they live, we have very little knowledge. But their general character is ftupidity, joined to a voracious and indifcriminating appetite for food. In oppofition to an almoft general law of Nature which fubfifts among other animals, fifhes devour, without diftinction, every fmaller or weaker animal, whether it belongs to a different fpecies, or to their own. In animals of a much higher order, voracity of appetite is feldom accompanied with ingenuity or elegance of tafte. When the principal attention of an animal is engroffed with any fenfual appetite, it is a fair conclufion that the mental powers are weak, becaufe they are chiefly employed upon the groffeft of all objects. If this obfervation be juft, fifhes muft be ranked among the moft ftupid animals of equal magnitude and activity.

The infant ftate of infects is a various and complicated fubject. After they efcape from the egg, they undergo fo many changes, and affume fuch a variety of forms, that it is difficult to determine the period of their exiftence which correfponds to the condition of infancy in the larger animals. Different ſpecies remain longer or ſhorter in the form of worms, caterpillars, or grubs, before they are changed into chryſalids, and afterwards into flies. When young, like other animals, they are ſmall and feeble: But, even in their moſt helpleſs condition, with a very few exceptions, Nature is their only nurſe. They require no aid from their parents, who, in general, are totally unacquainted with their progeny. But, as formerly obſerved, when treating of inſtinct, the mothers uniformly depoſit their eggs in ſituations which afford both protection and nouriſhment to their young. The parent fly, according to the ſpecies, invariably, unleſs reſtrained by neceſſity, depoſits her eggs upon particular plants, in the bodies of other animals, in the earth, or in water. Whenever, therefore, an inſect receives exiſtence in its primary form, all its wants are ſupplied. Though the mother, after the worms iſſue from the eggs, takes no charge of her offspring, and frequently does not exiſt at the time they come forth, yet, by an unerring and pure inſtinct, ſhe uniformly places them in ſituations where the young find proper nouriſhment, and every thing neceſſary to their feeble condition.

To this general law, by which inſects are governed, there are ſeveral exceptions. Bees, and ſome other flies, not only conſtruct neſts for their young, but actually feed, and moſt anxiouſly protect them.

From what has been ſaid concerning the infancy of animals, one general remark merits attention. Nature has uniformly, though by various modes, provided for the nouriſhment and preſervation of all animated beings while they are in an infantine ſtate. Though the human ſpecies continues long in that ſtate, the attachment and ſollicitude of both parents, inſtead of abating, in proportion to the time and labour beſtowed on their progeny, conſtantly augment, and commonly remain during life. The reciprocal affection of parents and children is one of the greateſt ſources of human happineſs. If the love of children were not ſtrong, and if it did not increaſe with time, the labour, the conſtant attention, the anxiety and fatigue of mothers would be unſufferable. But here Nature, whoſe wiſdom is always conſpicuous, makes affection brave every difficulty, and ſooth every pain. If a child be ſickly, and require uncommon care, the exertions of the mother are wonderfully ſupported: Pity unites with love; and theſe two paſſions become ſo ſtrong, that hardſhips, and fatigue of every kind, are ſuffered with chearfulneſs and alacrity.

With regard to the inferior tribes of animals, Nature has not been leſs provident. To quadrupeds and birds ſhe has given a ſtrong and marked affection for their offspring, as long as parental care is neceſſary. But, whenever the young begin to be in a condition to protect and provide for themſelves, the attachment of the parents gradually ſubſides; they become regardleſs of their offspring, at laſt baniſh them with blows, from their preſence, and, after that period, ſeem to have no knowledge of the objects which ſo lately had engroſſed all the attention of their minds, and occupied all the induſtry and labour of their bodies.—Here the dignity and ſuperiority of man appears in a conſpicuous light. Inſtead of loſing the knowledge of his offſpring after they arrive at maturity, his affection expands, and embraces grandchildren, and great-grandchildren, with equal warmth as if they had immediately originated from himſelf.

CHAP.

CHAPTER VIII.

Of the Growth, and Food, of Animals.

IT is a law of Nature, that all organized bodies, whether animal or vegetable, require food, in order to expand and ſtrengthen their parts when young, and to preſerve health and vigour after they have arrived at maturity. The food of animals is digeſted in the ſtomach and inteſtines: By this proceſs it is converted into chyle, and abſorbed by the lacteal veſſels, in the manner deſcribed in Chap. II. pag. 48. But how this chyle, or nutritious matter, after mingling with the general maſs of blood, contributes to the growth, and repairs the waſte of animal bodies, is a myſtery which probably never will be unfolded by human ſagacity. It has, however, like many other ſecrets of Nature, given riſe to ſeveral ingenious theories and conjectures, ſome of which ſhall be ſlightly mentioned.

Buffon conſiders the bodies of animals and vegetables as what he calls *internal moulds*. He ſays, that the matter of nutrition is not applied by juxta-poſition, but that it penetrates the whole maſs; that each part receives and applies thoſe particles only which are peculiar and neceſſary to its own nature; and that, by this means, the whole parts of the body are gradually and proportionally augmented. This nutritive matter, he remarks, is organic,. and ſimilar to the body itſelf; and hence the ſize of the body is increaſed, without any change in its figure or ſubſtance. The matter ejected by the different excretions he conſiders to be a ſeparation of the dead from the vivifying and organic parts of nouriſhment, which are diſtributed over the body by an active power: This power, ſimilar to that of gravity, penetrates the internal ſubſtance of the body, and attracts the organic particles, which are thus puſhed on through all its parts. As theſe organic particles are ſimilar to the body itſelf, their union with the different parts augments its ſize, without changing its figure. To unfold an embryo or germ, nothing more is requiſite than that it contain, in miniature, a body ſimilar to the ſpecies, and be placed in proper circumſtances for the acquiſition of freſh organic particles to increaſe its ſize and unfold its members. Hence nutrition, developement, and reproduction, are all effects of the ſame cauſe.

This account of the nutrition and growth of organic bodies has the appearance of an ingenious theory. But an attentive reader will eaſily perceive, that it contains no other information, than that animals and vegetables are nouriſhed and grow by the intervention of the nutritious particles of food. This is a fact univerſally known and admitted. But we are ſtill as ignorant as ever of the mode by which this myſterious operation is performed.

Other authors have ſuppoſed that the brain is a large gland; that the nerves diſtributed over the whole body are the ducts or canals of this gland; and that the principal uſe of the brain is to ſecrete nutritious matter, and to tranſmit it by the nerves to the various parts of the ſyſtem, in order to expand the different organs of which it is compoſed, or to repair the waſte they may have ſuffered from labour and other cauſes.

This theory presuppofes that the nerves are tubular, and contain a fluid: But both of thefe circumftances have hitherto eluded the refearch of the ableft anatomifts. Befides, the learned and indefatigable Doctor Monro, in his *Nervous Syftem*, has rendered it highly improbable that the nerves are the inftruments of nutrition. The Doctor reafons in the following manner. On comparing different animals, he remarks, we find no correfpondence between the fize of their brain, the rapidity of their growth, or the quantity of nourifhment they receive. An ox is fix times heavier than a man; but the brain of an ox weighs not above a fourth part of that of a man. On this fuppofition, an ox's brain muft fecrete twenty-four times more nourifhment than a portion equal to it of the human brain. In two years an ox acquires his full fize. His brain muft, of courfe, be fuppofed to tranfmit daily through the nerves two or three pounds of flefh, bones, &c. But the much larger brain of a man does not, in an equal time, add to his body a fiftieth part of that weight.

'In monfters, fays the Doctor, 'I have found the limbs very 'plump, though the brain was very fmall. Nay, in fome monfters, 'the head has been wanting, yet the limbs were as large and per'fect as common. In other monfters with one head and two bo'dies, I have found that the brain furnifhed the nerves of the head 'and fpinal marrow on the right fide of the monfter; yet the left 'fpinal marrow, at the top of which there was only a fmall medul'lary knob, about the fize of a large pea, was as perfect as the right 'one; and that body, and its limbs, were as large, and as well nou'rifhed, as thofe on the right fide. On the other hand, where there 'were two heads of the ordinary fize, and only one body, the limbs 'were not remarkable for their fize.

'We fee that organs, of which the nerves are fo fmall that we 'cannot trace them by diffection, as the bones, the placenta, &c.

'grow

'grow as quickly as the other organs, in which the nerves are large 'and numerous.

'A year after I had cut acroſs the ſciatic nerve of a living frog, I 'could not perceive that limb ſmaller than the other; yet it conti- 'nued to be inſenſible and motionleſs. Nay, when I had broken 'the bones of the inſenſible limb, or wounded the ſkin and fleſh, I 'found that the callus formed, and the wounds healed, as readily as 'if the nerve had been entire. The event was the ſame after di- 'viding, tranſverſely, the lower or poſterior end of the ſpinal mar- 'row of the frog.

'It is well known,' concludes our author, 'that, if powder 'of madder root is mixed with the food of a young animal, the 'bones become red; or, if a bone has been broken, that the callus 'joining its parts will be red. The ſerum of the blood, in the firſt 'place, is deeply tinged; but the red colour of the bones is not ſole- 'ly, nor even chiefly, owing to the coloured ſerum or blood circu- 'lating; for I have found, that, after injecting water into the veſſels 'till theſe were emptied of the blood, and that the water came out 'colourleſs, the tinge in the bones appeared equally deep, and was, 'therefore, plainly owing to a great quantity of the red earth added 'to the bones in the time of their growth. But this earth was not 'tranſmitted by the nerves; for the colour of theſe, as I found, re- 'mained unchanged.'

That the nutritious particles of food are conveyed by the arteries, and applied by their extremities to the various parts of animal bodies which require to be repaired or expanded, is an opinion not only beſt ſupported by facts, but adopted by all the more rational phyſiologiſts. The principal facts and arguments in ſupport of this theory ſhall now be mentioned.

 The

The chyle, as formerly remarked, is converted into blood. The glutinous part of the blood, known by the name of *coagulable lymph*, reſembles the white of an egg. That the white of an egg is the ſole nouriſhment of the chick before its excluſion, is an eſtabliſhed fact; and the concluſion, from analogy, that the lymph of blood is deſtined for the growth and reparation of animal bodies, is by no means unnatural. 'Without repeating,' ſays Dr Monro, 'our extreme 'uncertainty as to the tubular nature of the nerves, and the impro-'bability that canals ſo exceedingly minute as thoſe within the 'nerves muſt be, and of ſuch length, are deſtined for the convey-'ance of glue, do we not find, that this very matter is ſeparated by 'the exhalant branches of the arteries of the peritoneum, pleurae, 'and other ſhut ſacs, and univerſally, by the branches of the ar-'teries of the cellular membrane?—The kinds of matter neceſſary 'for the growth and nouriſhment of our ſeveral organs are ſo vari-'ous and different in their nature, that it is altogether incredible they 'can be furniſhed by the nerves: Thus, water is needed for the ex-'tenſion of the fore-part of the eye, viſcid matter for the cryſtalline 'and vitreous humours, earth for the growth of the bones, &c.; 'whereas we can as eaſily conceive theſe to be furniſhed by the ar-'teries, as that, in one place, they ſhould furniſh ſaliva, in another 'bile, &c.—As the waſte of the ſeveral organs is carried off by the 'veſſels, either circulating or abſorbent, why ſhould we doubt that 'the circulating fluids can add a particle in the place of one that has 'been carried off, or that an artery can ſupply what has been abſorb-'ed by a lymphatic vein? As it is granted that the ſecretion of all 'other kinds of matter in the bodies of animals is performed by the 'branches of the arteries, is it not incredible that there ſhould be 'an exception to the general rule in the ſecretion of the nouriſh-'ment? Surely that power which can convert the food into blood, 'and can change the blood into bile and ſaliva, is ſufficient to con-'vert it into nouriſhment.

'I will now add,' continues our author, 'that in calli, cicatrices, 'or accretions, there are numberlefs new formed veffels filled, in 'the living animal, with red blood, and which can readily be injec- 'ted. Nay, I found by experiment, that fuch new formed veffels, 'produced by the oppofite fides of a wound, unite into continued 'canals, or anaftamofe.—If, then, in a callus, new earthy or offeous 'fibres, and new veffels, can be formed by the original arteries, muft 'we not believe that the wafte of this earth, and of thefe veffels, 'can be ever after fupplied by the arteries which formed them? If 'fo, are we not to conclude, that the wafte of other arteries, and of 'other organs, is fupplied in the fame manner from the arteries? If 'the quantity of blood naturally circulating through a limb be dimi- 'nifhed, as by tying the trunk of the brachial artery, in the opera- 'tion for an aneurifm, the arm lofes part of its ftrength and fize; 'but the lofs is lefs than, at firft fight, might be expected; becaufe 'the anaftomofing (or uniting) canals foon come to be greatly en- 'larged.

'Upon the whole,' the Doctor concludes, 'there are few points 'in phyfiology fo clear, as, 1. That the arteries prepare, and direct- 'ly fecrete the nourifhment in all our organs; and, 2. That the 'nerves do not contain nor conduct the nourifhment, but, by 'enabling the arteries to act properly, contribute indirectly to nutri- 'tion.'

The ingenious Charles Bonnet endeavours to fhow, that the parts of all organifed bodies are contained, in miniature, in germs or buds; that thefe germs, when placed in proper fituations, gradually unfold and increafe in magnitude; that the various members of animals and vegetables are expanded, both longitudinally and laterally, by food adapted to their refpective natures; and that every germ actually includes

includes the rudiments of the whole animals or vegetables which are to proceed from it during all fucceffive generations.

With regard to vegetables, it is true, that the feed firft produces a fmall tree, which it contained in miniature within its lobes. At the top of this fmall tree a bud or germ is formed, which contains the fhoot or tree that is to fpring next feafon. In the fame manner, the fmall tree of the fecond year produces a bud which includes a tree for the third year; and this procefs uniformly goes on as long as the tree continues to vegetate. At the extremity of each branch, buds are likewife formed, which contain, in miniature, trees fimilar to that of the firft year. From thefe, and fimilar facts, it is concluded, that all thefe germs were contained in the original feed; for the firft bud was fucceeded by a fimilar bud, which was not unfolded till the fecond year, and the third bud was not expanded till the third year; and, of courfe, the feed may be faid to have contained not only the whole buds which would be formed in a hundred years, but all the feeds, and all the individuals, which would fucceffively arrive till the final deftruction of the fpecies.

Thefe facts are known and eftablifhed; but the reafoning deduced from them is fallacious, or, what amounts to the fame thing, is perfectly incomprehenfible. The feed is unqueftionably the origin or caufe of all future individuals, which may be infinite. But the idea that it really contained the germs of all the individuals which were to fpring from it as a fource, is not only abfurd, but exceeds all the powers of human imagination to conceive. Theories of this kind, of which there are too many in almoft every department of fcience, hardly merit examination. Every feed, and every animal, according to this doctrine, includes in its own body an infinite pofterity! If we affent to reafonings of this kind, we muft lofe ourfelves in the

labyrinths

labyrinths of infinity; and, inftead of throwing light upon the fubject, we fhall involve it in tenfold darknefs. All we know concerning the nature of growth and nutrition is extremely limited. We know that, in the animal kingdom, nutrition is performed by means of the blood, which is forcibly propelled through every part of the body by the action of the heart and arteries; and that vegetables, in a fimilar manner, are nourifhed by the afcenfion and diftribution of the fap. But, how the nutritive particles are applied to the various parts of organized bodies, and how they expand the organs, or repair their continual wafte and lofs of fubftance, we muft content ourfelves with remaining in perpetual ignorance.

In general, the food of animals, and particularly of the human fpecies, confifts of animal and vegetable fubftances, combined with water or other fluids. The Gentoo, and fome other fouthern nations, live entirely upon vegetable diet. From the accounts we have of the different regions of the earth, it appears, that the natives of warm climates, where the cultivation of plants is practifed, employ a greater proportion of vegetable food than in the more northern countries. The inhabitants of Lapland have little or no dependence on the fruits of the earth. They neither fow nor reap. They ftill remain, and, from the nature of their climate, muft forever remain, in the fhepherd ftate. Their comparative riches confift entirely of the number of rein-deer poffeffed by individuals. Their principal nourifhment is derived from the flefh and milk of thefe animals. In autumn, however, they catch great multitudes of fowls, moft of them of the game kind. With thefe, while frefh, they not only fupply their prefent wants, but dry and preferve them through the winter. They likewife kill hares, and other animals, which abound in the woods and mountains; but the flefh of the bear is their greateft delicacy. In their lakes and rivers, they have inexhauftible ftores

of

of fifhes, which, in fummer and autumn, they dry in the fun, or in ftoves, and in winter they are preferved by the froft. The Laplanders drink water, or animal oils; but never tafte bread or falt. They live in a pure air, and have fufficient exercife. Their conftitutions are attempered to the coldnefs of the climate; and they are remarkable for vigour and longevity. The gout, the ftone, the rheumatifm, and many other difeafes which torture the luxurious in milder climes, are totally unknown to them. With the few gifts which Nature has beftowed on them, they remain fatisfied, and live happily among their mountains and their ftorms. If fouthern nations afford examples of people who feed nearly on vegetables alone, the Laplanders furnifh one of the oppofite extreme; for they are almoft entirely carnivorous animals.

To Norway, Sweden, Germany, and Britain, the fame obfervation is applicable. In thefe countries, animal food is much more ufed than in France, Spain, Italy, Barbary, and the other fouthern regions of the globe. Many reafons may be affigned for thefe differences in the food of nations. The natural productions of the earth depend entirely on the climate. In warm climates, the vegetables which grow fpontaneoufly are both more luxuriant and more various. The number and richnefs of their fruits far exceed thofe of colder regions. From this circumftance, the natives muft be ftimulated to ufe a proportionally greater quantity of vegetable food; and we learn from hiftory, and from travellers, that this is actually the cafe. In cold countries, on the contrary, vegetables are not only fewer, but more rigid, and contain lefs nourifhment. The inhabitants, accordingly, are obliged to live principally on animal fubftances. If we examine the mode of feeding in different nations, it will be found, that, in proportion as men approach or recede from the poles, a greater or lefs quantity of animal and vegetable fubftan-

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ces are uſed in their diet. Cuſtom, laws, and religious rites, it muſt be allowed, produce conſiderable differences in the articles of food, among particular nations, which have no dependence on climate, or the natural productions of the earth. But when men are not fettered or prejudiſed by extraneous circumſtances, or political inſtitutions, the nature of their food is invariably determined by the climates they inhabit. The variety of food, in any country, is likewiſe greatly influenced by culture, and by imitation. Commerce occaſionally furniſhes new ſpecies of food, particularly of the vegetable kind. In Scotland, till about the beginning of this century, the common people lived almoſt entirely upon grain. Since that period, the culture and uſe of the potatoe, of many ſpecies of coleworts, and of fruits, have been introduced, and univerſally diffuſed through the nation.

Whether man was originally intended by Nature to live ſolely upon animal or vegetable food ? is a queſtion which has been much agitated both by the ancients and the moderns. Many facts and circumſtances concur in eſtabliſhing the opinion, that man was deſigned to be nouriſhed neither by animals nor vegetables ſolely, but by a mixture of both. Agriculture is an art, the invention of which muſt depend on a number of fortuitous circumſtances. It requires a long ſucceſſion of ages before ſavage nations learn this art. They depend entirely for their ſubſiſtence upon hunting wild animals, fiſhing, and ſuch fruits as their country happens ſpontaneouſly to produce. This has uniformly been the manner of living among all the ſavage nations of which we have any proper knowledge ; and ſeems to be a clear proof, that animal food is by no means repugnant to the nature of man. Beſides, the ſurface of the earth, even in the moſt luxuriant climates, and though aſſiſted by culture, is not capable of producing vegetable food in ſufficient quantity to ſupport the human race, after any region of it has become ſo populous as Britain, France, and many other nations. The general practice of mankind, when not reftrained by prejudice or fuperftition, of feeding promifcuoufly on animal and vegetable fubftances, is a ftrong indication that man is, partly at leaft, a carnivorous animal. The Gentoos, though their chief diet be vegetables, afford no proper argument againft this reafoning. They are obliged, by their religion, to abftain from the flefh of animals; and they are allowed to ufe milk, which is a very nourifhing animal food. Notwithftanding this indulgence, the Gentoos, in general, are a meagre, fickly, and feeble race. In hot climates, however, a very great proportion of vegetable diet may be ufed without any bad confequences.

Other arguments, tending to the fame conclufion, are derived, not from the cuftoms or practices of particular nations, but from the ftructure of the human body. All animals which feed upon vegetables alone, as formerly remarked, have ftomachs and inteftines proportionally larger than thofe that live folely on animal fubftances. Man, like the carnivorous tribes, is furnifhed with cutting and canine teeth, and, like the graminivorous, with a double row of grinders. The dimenfions of his ftomach and inteftines likewife hold a mean proportion between thefe two tribes of animals, which differ fo effentially in their characters and manners.—From thefe, and fimilar arguments, I have no hefitation to conclude, that a promifcuous ufe of animal and vegetable fubftances is no deviation from the original nature or deftination of mankind, whatever country they may inhabit.

With regard to the different proportions of animal and vegetable food which are moft accommodated to the health and vigour of mankind, no general rule can be given that could be applicable to different climates, and to the different conftitutions of individuals. Animal food, it is certain, gives vigour to the body, and may be

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ufed more liberally by the active and laborious than by thofe who lead a ftudious and fedentary life. A great proportion of vegetable food, and particularly of bread, is confidered, by the moft eminent phyficians, as beft adapted for men who are fond of fcience and literature; for full meals of animal food load the ftomach, and feldom fail to produce dulnefs, yawning, indolence, and many difeafes which often prove fatal.

The remainder of this chapter, from unavoidable caufes, muft confift of obfervations of a more defultory kind.

Moft animals, when they live long on a particular fpecies of food, are apt to be affected with difeafes, which generally arife from coftivenefs, or its oppofite. The guiney-pigs, after being confined for fome time to coleworts, contract a loofenefs, which often terminates in death. But, when thofe animals are at full liberty, they prevent this effect, by an inftinct which teaches them to make frequent changes from moift to dry food: If they are reftrained in their choice, they will eat, as a fuccedaneum, paper, linen, and even woollen cloths.

Though fome animals, and many vegetables, would be noxious to man, if ufed as food, yet, in general, that matter is more regulated by chance and cuftom than by rational motives. By experience, and the aid of our fenfes, we acquire a tollerable facility of diftinguifhing falutary from noxious food. Other animals felect their food inftinctively; and their choice is chiefly determined by the fenfe of fmelling. The fpaniel hunts his prey by the fcent; but the grey-hound depends principally upon the ufe of his eye. When the grey-hound lofes fight of a hare, he inftantly gives up the chace, and looks keenly around him, but never applies his nofe, in order to difcover the track. Some rapacious animals, as wolves and ravens, difcover carrion at diftances, which, if we were to judge from our own fenfe of fmelling, would appear to be altogether incredible. Others, as eagles, hawks, gulls, &c. furprife us no lefs by the acutenefs of their fight. They perceive, from great heights in the air, mice, fmall birds, and minute fifhes in the water.

One great caufe of the diffufion of animals over every part of the globe, is to be derived from the diverfity of appetites for particular fpecies of food, implanted by Nature in the different tribes. Some fifhes are only to be found in certain latitudes. Some animals inhabit the frigid, others the torrid zones; fome frequent deferts, mountains, woods, lakes, and meadows. In their choice of fituation, they are uniformly determined to occupy fuch places as furnifh them with food accommodated to their natures. Monkies, the elephant, and rhinoceros, fix on the torrid zone, becaufe they feed on vegetables which flourifh there during the whole year. The rein-deer inhabit the cold regions of the north, becaufe thefe countries produce the greateft quantity of the lichen, a fpecies of mofs, which is their beloved food. The pelican makes choice of dry and defert places to lay her eggs. When her young are hatched, fhe is obliged to bring water to them from great diftances. To enable her to perform this neceffary office, Nature has provided her with a large fac, which extends from the tip of the under mandible of her bill to the throat, and holds as much water as will fupply her brood for feveral days. This water fhe pours into the neft to cool her young, to allay their thirft, and to teach them to fwim. Lions, tigers, and other rapacious animals, refort to thefe nefts, drink the water, and are faid not to injure the young *. The goat afcends the rocky precipice, to crop the leaves of fhrubs, and other favourite plants. The floth and the fquirrel feed upon the leaves and the fruit of trees,

* Amoen. Acad. vol. 2. p. 41.

trees, and are, therefore, furniſhed with feet which enable them to climb. Water-fowls live upon fiſhes, inſects, and the eggs of fiſhes. Their bill, neck, wings, legs, and whole ſtructure, are nicely fitted for enabling them to catch the food adapted to their natures. Their feeding upon the eggs of fiſhes accounts for that variety of fiſhes which are often found in lakes and pools on the tops of hills, and on high grounds remote from the ſea and from rivers. The bat and the goat-ſucker fly about during the night, when the whole air is filled with moths, and other nocturnal inſects. The bear, who acquires a prodigious quantity of fat during the ſummer, retires to his den, when proviſions fail him, in winter. For ſome months, he receives his ſole nouriſhment from the abſorption of the fat which had been previouſly accumulated in the cellular membrane.

A glutton, brought from Siberia to Dreſden, eat every day, ſays M. Klein, thirty pounds of fleſh without being ſatisfied. This fact indicates an amazing digeſtive power in ſo ſmall a quadruped; for the ſtory of his ſqueezing his ſides between two trees, in order to make him diſgorge, is a mere fable *.

Siberia, Kamtſchatka, and the polar regions, are ſuppoſed to be the abodes of miſery and deſolation. They are, it muſt be allowed, infeſted with numerous tribes of bears, foxes, gluttons, and other rapacious animals. But it ſhould be conſidered, that theſe voracious animals ſupply the natives with both food and clothing. To elude the attacks of ferocity, and to acquire poſſeſſion of the ſkins and carcaſſes of ſuch creatures, the induſtry and dexterity of ſavage nations are excited. The furs are demanded by foreigners. The inhabitants by this means learn commerce and the arts of life; and, in the progreſs of time, bears and wild beaſts become the inſtruments of poliſhing

* Gaz. Litteraire, vol. I. p. 481.

polifhing a barbarous people. Thus, the moft fubftantial good often proceeds from apparent misfortune.

There is hardly a plant that is not rejected as food by fome animals, and ardently defired by others. The horfe yields the common water-hemlock to the goat, and the cow the long-leafed water-hemlock to the fheep. The goat, again, leaves the aconite, or bane-berries, to the horfe, &c. Plants which afford proper nourifhment to fome animals, are by others avoided, becaufe they would not only be hurtful, but even poifonous. Hence no plant is abfolutely deleterious to animal life. Poifon is only a relative term. The euphorbia, or fpurge, fo noxious to man, is greedily devoured by fome of the infect tribes.

It is a maxim univerfally received, that every animal, after birth, grows, or acquires an augmentation of fize. The fpider-fly, however, affords an exception. The mother lays an egg fo difproportionally large, that no perfon, without the aid of experience, could believe it to have been produced by this infect. When the egg is hatched, a fly proceeds from it, which, at the moment of birth, equals the parent in magnitude. Upon a ftricter examination of this egg, it has been difcovered, that the infect, while in the belly of its mother, undergoes a transformation into the nymph or chryfalis ftate; and that, inftead of a worm, a fly is produced from it, of the fame dimenfions as the parent. This difcovery, however, does not diminifh our wonder, that any animal fhould actually give birth to a fubftance as large as its own body, and that its fize fhould never afterwards receive any augmentation *.

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* Reaumur, tom. 6. p. 48.;—and Bonnet, tom. 3. p. 363.—369.

When caterpillars, ſome time before their change, are deprived of food, they diminiſh to at leaſt one half of their former ſize. Their chryſalids, of courſe, as well as the butterflies which proceed from them, are proportionally ſmall. From this fact we learn the importance of feeding all young animals well till they acquire their full growth.

It is a remark of the ingenious Reaumur, that ſuch inſects as feed upon dead carcaſſes, and whoſe fecundity is great, never attack live animals. The fleſh-fly depoſits her eggs in the bodies of dead animals, where her progeny receive that nouriſhment which is beſt ſuited to their conſtitution. But this fly never attempts to lay her eggs in the fleſh of ſound and living animals. If Nature had determined her to obſerve the oppoſite conduct, men, quadrupeds, and birds, would have been dreadfully afflicted by the ravages of this ſingle inſect. Leſt it might be imagined that the fleſh-fly ſelected dead, inſtead of live animals, becauſe, in depoſiting her eggs, ſhe was unable to pierce the ſkin of the latter, M. de Reaumur made the following experiment, which removed every doubt that might ariſe on the ſubject. He carefully pulled of all the feathers from the thigh of a young pigeon, and applied to it a thin ſlice of beef, in which there were hundreds of maggots. The portion of beef was not ſufficient to maintain them above a few hours. He fixed it to the thigh by a bit of gauze; and he prevented the pigeon from moving, by tying its wings and leggs. The maggots ſoon ſhewed that their preſent ſituation was diſagreeable to them. Moſt of them retired from under the ſlice of beef; and the few that remained periſhed in a ſhort time. Their death was probably occaſioned by the degree of heat in the pigeon's body being greater than their conſtitution could bear. Upon the ſame pigeon M. de Reaumur performed another experiment. He took off the ſkin from its thigh, laid bare the fleſh, and applied immediately another ſlice of beef full of maggots. The animals

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difcovered evident marks of uneafinefs; and all of them that remained on the flefh of the pigeon were deprived of life, as in the former experiment, in lefs than an hour. Thus the degree of heat that is neceffary to fuch worms as inhabit the interior parts of animals, is deftructive to thofe fpecies which Nature has deftined to feed upon the flefh of dead animals. Hence the worms fometimes found in ulcerous fores, muft belong to a different fpecies from thofe upon which the above experiments were made.

The growth of fome worms, which feed upon animal or vegetable fubftances, is extremely rapid. Redi remarked, that thefe creatures, the day after they efcaped from the egg, had acquired at leaft double their former fize. At this period he weighed them, and found that each worm weighed feven grains; but that, on the day preceding, it required from twenty-five to thirty of them to weigh a fingle grain. Hence, in about the fpace of twenty-four hours, each of thefe worms had become from 155 to 210 times heavier than formerly. This rapidity of growth is remarkable in thofe maggots which are produced from the eggs of the common flefh-fly.

Before we difmifs this fubject, a few obfervations on that power, inherent in all animal bodies, of diffolving, and converting into chyle, every nutritive fubftance thrown into the ftomach, merit attention.

In order to explain the procefs of digeftion, fome phyficians and philofophers have had recourfe to mechanical force, and others to chemical action. The fupporters of mechanical force maintained, that the ftomachs of all animals comminuted, or broke down into fmall portions, every fpecies of food, and prepared it for being converted into chyle. The chemical philofophers, on the contrary, fupported the opinion, that the

the food was diſſolved by a fermentation induced by the ſaliva and gaſtric juices. The diſputes which naturally aroſe from theſe ſeemingly oppoſite theories, ſtimulated the inquiries of the ingenious, and produced ſeveral curious and important diſcoveries. Reaumur, M'Bride, Stevens, Spalanzani, Hunter, have all exerted their induſtry and talents upon this ſubject. To give even an abridged view of their different labours would be both tedious, and, at the ſame time, would not coincide with the deſign of this work. I ſhall therefore confine myſelf to ſome reſults of their experience and labours. Spalanzani, who is a voluminous writer on this ſubject, relates not only the diſcoveries of his predeceſſors, but has enriched his work with numerous experiments and obſervations made by himſelf. In his inveſtigation of the proceſs of digeſtion, and the action of the ſtomach, he obſerves the following order:

1. He treats of animals with ſtrong muſcular ſtomachs, as common fowls, turkeys, ducks, geeſe, pigeons, &c. 2. Of animals with ſtomachs of an intermediate conſiſtence, as crows, herons, &c. 3. Of animals with membranous ſtomachs, as frogs, lizards, earth and water ſnakes, vipers, fiſhes, ſheep, the ox, the horſe, the owl, the falcon, the eagle, the cat, the dog, man, &c.

With regard to birds which are furniſhed with muſcular ſtomachs, or gizzards, Spalanzani, in imitation of Reaumur, procured ſmall glaſs and metal balls and tubes, perforated with many holes. Theſe he filled with different kinds of food, and forced them down the throats of common fowls, turkeys, &c. He filled balls with barley, or other grains, in their entire ſtate, and allowed them to remain in the ſtomachs of ducks, turkeys, and other fowls, for twenty-four, and, in ſome caſes, for forty-eight hours. He then killed the animals, took the balls out of their ſtomachs, and, after examining the grains attentively, he could not diſcover that the gaſtric juice, to the action of which they were fully expofed by the numerous holes in the balls, had made the fmalleft impreffion upon them. They fuffered no diminution of fize, and exhibited no marks of diffolution. Thefe experiments he often repeated upon a number of fowls provided with mufcular ftomachs, and the event was uniformly the fame: In no inftance did the gaftric juice produce any folvent effect upon the grain contained in the balls. After thefe unfuccefsful attempts, he fufpected, that, though the gaftric juice was unable to diffolve grains in their entire ftate, it might act as a menftruum upon them when fufficiently mafticated or bruifed. To afcertain this point, he afterwards filled his balls with bruifed grains, and introduced them into the ftomachs of different fowls, as cocks, ducks, turkeys, wood-pigeons, &c. In all the numerous trials he made with bruifed grain, he invariably found, that the grain was more or lefs diffolved in proportion to the time the balls were allowed to remain in the ftomach.

Reaumur and Spalanzani, in the courfe of their experiments upon the digeftion of birds with mufcular ftomachs, difcovered a wonderful comminuting force which thefe ftomachs poffefs. When tin tubes full of grain were thrown into the ftomachs of turkeys, and allowed to continue there a confiderable time, they were found to be broken, crufhed, or diftorted, in a moft fingular manner. 'Having found,' fays Spalanzani, 'that the tin tubes which I ufed for 'common fowls were incapable of refifting the ftomach of turkeys, 'and not happening at that time to be provided with any tin plate 'of greater thicknefs, I tried to ftrengthen them, by foldering to the 'ends two circular plates of the fame metal, perforated only with a 'few holes for the admiffion of the gaftric fluid. But this contri'vance was ineffectual; for, after the tubes had been twenty hours 'in the ftomach of a turkey, the circular plates were driven in,

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'and ſome of the tubes were broken, ſome compreſſed, and ſome 'diſtorted, in the moſt irregular manner *.'

The ſmooth and blunt ſubſtances formerly employed, Spalanzani remarks, though ſo violently acted upon, could not injure the ſtomach; he therefore tried what effects would be produced by ſharp bodies thrown into the gizzards of fowls. He found that the ſtomach of a cock, in the ſpace of twenty-four hours, broke off the angles of a piece of rough jagged glaſs. Upon examining the gizzard, no wound or laceration appeared. 'Twelve ſtrong tin needles,' ſays Spalanzani, 'were firmly fixed in a ball of lead, the points 'projecting about a quarter of an inch from the ſurface. Thus 'armed, it was covered with a caſe of paper, and forced down the 'throat of a turkey. The bird retained it for a day and a half 'without ſhowing the leaſt ſymptom of uneaſineſs. Why the ſto-'mach ſhould have received no injury from ſo horrid an inſtrument 'I cannot explain: The points of the twelve needles were broken 'off cloſe to the ſurface of the ball, except two or three, of which 'the ſtumps projected a little higher.—Two of the points of the 'needles were found among the food; the other ten I could not 'diſcover, either in the ſtomach or the long track of the inteſtines; 'and therefore concluded, that they had paſſed out at the vent †.'

The ſame author made a ſecond experiment ſeemingly ſtill more cruel. He fixed twelve ſmall lancets, very ſharp both at the points and edges, in a ſimilar ball of lead. 'The lancets,' ſays he, 'were 'ſuch as I uſe for the diſſection of ſmall animals. The ball was 'given to a turkey cock, and left eight hours in the ſtomach; at 'the expiration of which time that organ was opened; but no-'thing appeared except the naked ball, the twelve lancets having

* Spalanzani's Diſſertations, vol. 1. p. 12.

† Ibid. p. 18.

'been broken to pieces. I difcovered three of them in the large 'inteftines, pointlefs, and mixed with the excrements; the other 'nine were miffing, and had probably been voided at the vent. 'The ftomach was as found and entire as that which had received 'the needles. Two capons, of which one was fubjected to the ex-'periment with the needles, and the other with the lancets, fuftain-'ed them equally well.'

The fmall ftones fo commonly found in the ftomachs of many of the feathered tribes, have been fuppofed to fheath the gizzard, and to enable it to digeft, or at leaft to break down into fmall fragments, glafs, iron, wood, ftones, and other hard, and even fharp-pointed, fubftances. Spalanzani has endeavoured to prove, that the mufcular action of the gizzard is equally powerful, whether the fmall ftones are prefent or abfent. To afcertain this point, he took wood-pigeons the moment they efcaped from the egg, fed and nurfed them himfelf till they were able to peck: 'They were then,' continues our author, 'confined in a cage, and fupplied at firft with 'vetches foaked in warm water, and afterwards in a dry and hard 'ftate. In a month after they had begun to peck, hard bodies, 'fuch as tin tubes, glafs globules, and fragments of broken glafs, 'were introduced with the food. Care was taken that each pigeon 'fhould fwallow only one of thefe fubftances. In two days after-'wards they were killed. Not one of the ftomachs contained a 'fingle pebble; and yet the tubes were bruifed and flattened, and 'the fpherules and bits of glafs blunted and broken: This happened 'alike to each body; nor did the fmalleft laceration appear on the 'coats of the ftomach.' From feveral experiments of a fimilar nature, and accompanied with the fame events, Spalanzani concludes this fubject with that candour which is always a genuine characteriftic of a real philofophic fpirit. Upon the whole, 'it appears,' fays he, 'that thefe fmall ftones are not at all neceffary to the tritura-

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' tion of the firmeft food, or the hardeft foreign fubftance, contrary ' to the opinion of many anatomifts and phyfiologifts, as well an- ' cient as modern. I will not, however, deny, that, when put in ' motion by the gaftric mufcles, they are capable of producing fome ' effect on the contents of the ftomach.'

The celebrated Mr John Hunter, in his *Obfervations on Digeftion* *, fairly quotes the modeft conclufion of Spalanzani. But he infifts that ftones are extremely ufeful in the comminution of grain, and other fubftances, which conftitute the food of many fowls. ' In ' confidering,' Mr Hunter remarks, ' the ftrength of the gizzard, ' and its probable effects when compared with the human ftomach, ' it muft appear that the gizzard is, in itfelf, very fit for trituration. ' We are not, however, to conclude, that ftones are entirely ufelefs; ' for, if we compare the ftrength of the mufcles of the jaws of ani- ' mals who maftigate their food, with thofe of birds who do not, ' we fhall fay, that the parts are well calculated for the purpofe of ' maftication; yet we are not from thence to infer, that the *teeth* ' in fuch jaws are ufelefs, even although we have proof that the ' *gums* do the bufinefs when the teeth are gone. If ftones are of ' ufe, which we may reafonably conclude they are, birds have an ' advantage over animals having teeth, fo far as ftones are *always* ' to be found, while the teeth are not renewed.—If we conftantly ' find in an organ fubftances which can only be fubfervient to the ' functions of that organ, fhould we deny them that ufe, although ' the part can do its office without them?—The ftones affift in ' grinding down the grain, and, by feparating its parts, allow the ' gaftric juice to come more readily in contact with it.'

* Page 156.

The next ſeries of experiments were made upon animals with what Spalanzani denominates intermediate ſtomachs between the muſcular and membranous, as ravens, crows, herons, &c. The power and action of theſe intermediate ſtomachs are ſuperior to thoſe of the membranous kind, but greatly inferior to thoſe of the muſcular. The tin tubes, or balls, which pigeons and turkeys ſoon flatten and disfigure, remain unaltered in the ſtomach of crows. Their gaſtric muſcles, however, are by no means inert. Though they are unable to compreſs or diſtort tin tubes, they are capable of producing this effect upon thin tubes of lead. Birds whoſe ſtomachs are of an intermediate kind, with regard to the thickneſs and ſtrength of their muſcular coats, may be denominated *omnivorous*. They eat graſs, herbs, grain, and fleſh of every kind. When we make experiments, upon the digeſtive powers of gallinaceous birds, the animals muſt be killed before we can learn what effects have been produced on the ſubſtances incloſed in the balls or tubes. But, on crows and ravens, experiments of this kind may be repeated as often as we pleaſe, without deſtroying a ſingle individual. Subſtances which they are incapable of digeſting, as metallic tubes, they have the power of diſgorging, or returning by the mouth, in the ſame manner as falcons, and other birds of prey, throw up the feathers and hair of the animals they have devoured. In birds of prey, this vomiting is commonly performed every twenty-four hours; but, in crows, it happens at leaſt every nine, and not unfrequently every two or three hours.

Spalanzani, as in the former experiments, thruſt down perforated tubes, filled with different ſubſtances, into the ſtomachs of crows. Theſe tubes were uniformly thrown up by the animals in a few hours. When the tubes were filled with entire grains, as wheat or beans, he found that the gaſtric juice, though the tubes, by being repeatedly forced down, continued in the ſtomach for the ſpace of

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forty-eight hours, had exerted no ſolvent power. As the huſks of the ſeeds reſiſted the action of the gaſtric juice, he bruiſed them, and repeated the experiment. 'Four tubes full of this coarſe flour,' ſays he, 'were given to a crow: They remained eight hours in the 'ſtomach, and proved the juſtneſs of my ſuſpicion; for, upon ex-'amining the contents, I found above a fourth part wanting. This 'could ariſe from no other cauſe but ſolution in the gaſtric liquor, 'with which the remainder was fully impregnated. Another ob-'ſervation concurred in proving the ſame propoſition: The largeſt 'bits of wheat and bean were evidently much diminiſhed: This 'muſt have been owing to the gaſtric liquor having corroded and 'diſſolved good part of them, as the nitrous acid, diluted with a 'large quantity of water, gradually conſumes calcareous ſubſtances. 'I replaced what remained of the ſeeds in the tubes, and committed 'them again to the ſtomach, wherein they remained, at different 'intervals, twenty-one hours; at the end of which period they 'were entirely diſſolved; nothing being left but ſome pieces of huſk, 'and a few inconſiderable fragments of the ſeeds. Wheat and beans 'floating looſe in the cavity of the ſtomach, undergo the ſame alte-'ration as in the tubes. When I fed my crows with theſe ſeeds, I 'obſerved, that, before they ſwallowed them, they ſet them under 'their feet, and reduced them to pieces by repeated ſtrokes of their 'long and heavy beaks: And now they digeſted them very well; 'nay, this proceſs was very rapid in compariſon of that which took 'place within the tubes. But, when the birds, either from exceſ-'ſive hunger, or violence, ſwallowed the ſeeds entire, the greateſt 'part of them paſſed out entire at the anus, or were vomited. We 'cannot, therefore, be ſurpriſed, that the gaſtric juice could not diſ-'ſolve them within the tubes, ſince it was incapable of effecting 'this proceſs within the cavity of the ſtomach, where its ſolvent 'power is far ſuperior.'

Similar

Similar experiments were made with French beans, peafe, nut-kernels, bread, apples, and different kinds of flefh and fifh, all of which were diffolved, both in tubes, and in the cavity of the ftomach, by the gaftric juice.

Spalanzani finifhes his experiments on digeftion with thofe animals which have thin membranous ftomachs. This clafs comprehends an immenfe number of fpecies, as man, quadrupeds, fifhes, reptiles. In thefe the coats of the ftomach feem to have little or no action upon their contents, the gaftric juice being fully fufficient to break down the food, and reduce it to a pulp.

With regard to man, Dr Stevens, in an Inaugural Differtation concerning Digeftion, publifhed at Edinburgh in the year 1777, made feveral experiments upon a German, who gained a miferable livelyhood by fwallowing ftones for the amufement of the people. He began this ftrange practice at the age of feven, and had at that time continued it about twenty years. He fwallowed fix or eight ftones at a time, fome of them as large as a pigeon's egg, and paffed them in the natural way. Dr Stevens thought this poor man would be an excellent fubject for afcertaining the folvent power of the gaftric juice in the human ftomach. The Doctor, accordingly, made ufe of him for this purpofe. He made the German fwallow a hollow filver fphere, divided into two cavities by a partition, and perforated with a great number of holes, capable of admitting an ordinary needle. Into one of thefe cavities he put four fcruples and a half of raw beef, and into the other five fcruples of raw bleak. In twenty-one hours the fphere was voided, when the beef had loft a fcruple and a half, and the fifh two fcruples. A few days afterwards, the German fwallowed the fame fphere, which contained, in one cavity, four fcruples and four grains of raw, and, in the other, four fcruples and eight grains of boiled beef. The fphere was returned in forty-three hours: The raw fleſh had loſt one ſcruple and two grains, and the boiled one ſcruple and ſixteen grains. Suſpecting that, if theſe ſubſtances were divided, the ſolvent would have a freer acceſs to them, and more of them would be diſſolved, Dr Stevens procured another ſphere, with holes large enough to receive a crow's quill. He incloſed ſome beef in it a little maſticated. In thirty-eight hours after it was ſwallowed, it was voided quite empty. Perceiving how readily the chewed meat was diſſolved, he tried whether it would diſſolve equally ſoon without being chewed. With this view, he put a ſcruple and eight grains of pork into one cavity, and the ſame quantity of cheeſe into the other. The ſphere was retained in the German's ſtomach and inteſtines forty-three hours; at the end of which time, not the ſmalleſt quantity of either pork or cheeſe was to be found in the ſphere. He next ſwallowed the ſame ſphere, which contained, in one partition, ſome roaſted turkey, and ſome boiled ſalt herring in the other. The ſphere was voided in forty-ſix hours; but no part of the turkey or herring appeared; for both had been completely diſſolved. Having diſcovered that animal ſubſtances, though incloſed in tubes, were eaſily diſſolved by the gaſtric juice, the Doctor tried whether it would produce the ſame effect upon vegetables. He, therefore, incloſed an equal quantity of raw parſnep and potatoe in a ſphere. After continuing forty-eight hours in the alimentary canal, not a veſtige of either remained. Pieces of apple and turnip, both raw and boiled, were diſſolved in thirty-ſix hours.

It is a comfortable circumſtance, that no animal, perhaps, except thoſe worms which are hatched in the human inteſtines, can reſiſt the diſſolving power of the gaſtric juice. Dr Stevens incloſed live leeches, and earth-worms, in different ſpheres, and made the German ſwallow them. When the ſpheres were diſcharged, the animals were not only deprived of life, but completely diſſolved, by the operation of this powerful menſtruum. Hence, if any live reptile ſhould chance to be ſwallowed, we have no reaſon to apprehend any danger from ſuch an accident.

The German left Edinburgh before the Doctor had an opportunity of making a farther progreſs in his experiments. He therefore had recourſe to dogs and ruminating animals. In the courſe of his trials upon the ſolvent power in the gaſtric fluid of dogs, he found that it was capable of diſſolving hard bones, and even balls of ivory; but that, in equal times, very little impreſſion was made upon potatoes, parſnep, and other vegetable ſubſtances. On the contrary, in the ruminating animals, as the ſheep, the ox, &c. he diſcovered, that their gaſtric juice ſpeedily diſſolved vegetables, but made no impreſſion on beef, mutton, and other animal bodies. From theſe laſt experiments, it appears that the different tribes of animals are not leſs diſtinguiſhed by their external figure, and by their manners, than by the quality and powers of their gaſtric juices. Dogs are unable to digeſt vegetables, and ſheep and oxen cannot digeſt animal ſubſtances. As the gaſtric juice of the human ſtomach is capable of diſſolving, nearly with equal eaſe, both animals and vegetables, this circumſtance affords a ſtrong, and almoſt an irreſiſtible, proof, that Nature originally intended man to feed promiſcuouſly upon both.

Live animals, as long as the vital principle remains in them, are not affected by the ſolvent powers of the ſtomach. ‘ Hence it is,’ Mr Hunter remarks, ‘ that we find animals of various kinds living ‘ in the ſtomach, or even hatched and bred there; but the moment ‘ that any of theſe loſe the living principle, they become ſubject to ‘ the digeſtive powers of the ſtomach. If it were poſſible, for example, for a man's hand to be introduced into the ſtomach of a ‘ living animal, and kept there for ſome conſiderable time, it would ‘ be found, that the diſſolvent powers of the ſtomach could have no

‘ effect

'effect upon it: But, if the ſame hand were ſeparated from the body, and introduced into the ſame ſtomach, we ſhould then find, that the ſtomach would immediately act upon it. Indeed, if this were not the caſe, we ſhould find that the ſtomach itſelf ought to have been made of indigeſtible materials; for, if the living principle was not capable of preſerving animal ſubſtances from undergoing that proceſs, the ſtomach itſelf would be digeſted. But we find, on the contrary, that the ſtomach, which at one inſtant, that is, while poſſeſſed of the living principle, was capable of reſiſting the digeſtive powers which it contained, the next moment, viz. when deprived of the living principle, is itſelf capable of being digeſted, either by the digeſtive powers of other ſtomachs, or by the remains of that power which it had of digeſting other things.'

When bodies are opened ſome time after death, a conſiderable aperture is frequently found at the greateſt extremity of the ſtomach. 'In theſe caſes,' ſays Mr Hunter, 'the contents of the ſtomach are generally found looſe in the cavity of the abdomen, about the ſpleen and diaphragm. In many ſubjects, this digeſtive power extends much farther than through the ſtomach. I have often found, that, after it had diſſolved the ſtomach at the uſual place, the contents of the ſtomach had come into contact with the ſpleen and diaphragm, had partly diſſolved the adjacent ſide of the ſpleen, and had diſſolved the ſtomach quite through; ſo that the contents of the ſtomach were found in the cavity of the thorax, and had even affected the lungs in a ſmall degree.'

CHAPTER IX.

Of the Sexes of Animals and Vegetables.

SECTION I.

Of the Sexes of Animals.

ALL the larger and more perfect animals are diftinguifhed by the fexes of male and female. The bodies of males, though not without exceptions, are, in general, ftronger, larger, and more active, than thofe of the females. In the human fpecies, the male is not only larger than the female, but his mufcular fibres are firmer and more compact, and his whole frame indicates a fuperior ftrength and robuftnefs of texture. He does not acquire his full growth, and beft form, till he arrives at the age of thirty years. But, in women, the parts are rounder, and their mufcular fibres more feeble and lax than thofe of men, and their growth and form are perfect at the age of twenty. A fimilar obfervation is applicable to the minds of the two fexes. Man is, comparatively, a bold, generous, and enterprifing animal. Women, on the contrary, are timid, jealous, and difpofed to actions which require lefs agility and ftrength. Hence they

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are entitled to claim, and, by their amiable weakneſſes, they actually receive our protection. Men are endowed with majeſty of figure and force of mind; but beauty, and the graces, are the proper characteriſtics of women. The laxity and ſoftneſs of their texture may, in ſome meaſure, account for the timidity and liſtleſſneſs of their diſpoſition; for, when the bodies of men are relaxed by heat, or by any other cauſe, their minds become not only timid, but weak, undetermined, and inactive.

The ſocial intercourſe of women ſoftens the diſpoſitions, and ſoothes the cares and labours of the men. Their little female humours, caprices, and follies, give riſe to many exertions of virtue. They excite in us compaſſion, humanity, and tenderneſs of affection. The delicacy of their bodies, and the weakneſs of their minds, require our ſupport and protection. In return, the gentle and inſinuating manners of the women have a direct tendency to ſoften and ſmooth the natural roughneſs of men. In moſt governments, women have the entire management and training of children, till their characters and diſpoſitions are almoſt fixed for life. This is an important office; and would require more education and ſenſe than they commonly receive either from nature or art. But their perſevering and unremitting attention to their charge, eſpecially when children are ſick or weakly, is ſo truly aſtoniſhing, that no man could have patience to perform the laborious and painful taſk. Women are likewiſe ſaid to ſuffer bodily pain with more reſolution than men. Women reaſon rapidly; but their reaſoning, though often acute, is ſeldom ſolid.

Modeſty is one of the moſt diſtinguiſhing and attractive characteriſtics of the female ſex. This is the great defence with which Nature has armed them againſt the artifices and deceit of the males. Modeſty has a double effect: It both attracts and repels. It heigh-

tens

tens the defire of the male, and deters him from rudenefs, or improper behaviour. Were women deprived of this amiable quality, all their charms would vanifh, and the ardour of love would be extinguifhed. It is, therefore, not only the intereft of females to cultivate modefty, but to guard, with the moft anxious attention, againft the fmalleft incroachments. Every attack, however apparently infignificant, fhould be repelled with fpirit and intrepidity. To men of fenfibility, a fingle glance of the eye will tell them that their conduct is improper, and make them not only inftantly defift, but prevent every future attempt. There is no part of the female character which men revere fo much as modefty. It is the brighteft and moft valuable jewel with which a woman can be adorned. A fine woman without modefty, inftead of gaining the affections of men, becomes an object of contempt, and even of difguft. It is equally the intereft of men to cherifh, and not to injure by indelicacy, a quality from which they derive fo much pleafure and advantage.

It is not unworthy of remark, that modefty is by no means confined to the human fpecies. Evident traces of it are difcoverable in the brute creation. Even fo low as the infect tribes, moft females repel the firft attacks of the males. If this is not modefty, it has all the effects of it; for it heightens the refpect and affection of the males, and makes them employ every alluring art to procure the regard of the female.

It is a curious fact, that moft carnivorous quadrupeds are more averfe from devouring women than men. The bears of Kamtfchatka follow the women when gathering wild fruits in the woods, and, though moft rapacious animals, do them no farther harm than robbing them of part of the fruit *. The afpect of man being more bold,

* Gazette Literaire, vol. 1. p. 482.

bold, may, perhaps, create an idea of competition and danger, and excite the ferocity and courage of the animal. There ſeems to be an inſtinctive reſpect, if not dread, of the human kind implanted in moſt animals. If this be the caſe, the above fact amounts to a high compliment to the women; for they receive more favour from the brute creation than the men.

With regard to animals, in general, the intercourſe of ſexes is neceſſary for the multiplication of the ſpecies. But, as formerly remarked *, ſeveral of the lower tribes are enabled to multiply without the intervention of ſexes. In ſome animals, both ſexes are combined in each individual. The earth-worm, ſnails, and ſeveral ſhell-fiſhes, are hermaphrodites; and yet the conjunction of two is neceſſary for their multiplication. Mr Adanſon, in his Account of Senegal, mentions ſome ſhell-animals which, in order to produce, require the union of three individuals. In the polypus, no appearance of ſexual diſtinction has hitherto been diſcovered. Nature, however, has not denied them the power of multiplication, which is effected in a very ſingular manner †. Caterpillars of every denomination are totally deſtitute of ſexes, and are incapable, while they remain in that ſtate, of multiplying their ſpecies. But, after their transformation into flies, the diſtinction of ſexes is apparent, and their fertility is exceedingly great.

Among the larger animals, the difference of ſize and figure between males and females is not remarkable. The moſt ſtriking diſtinctions ariſe from the horns, the tuſks, the creſt, &c. which adorn the head of the male, and are often wanting in the female. But, among the inſect tribes, ſome males differ ſo greatly from the females, that they have the appearance of belonging to a ſeparate genus.

* See chap. 1. pag. 30. &c. † Ibid.

nus. In ſome butterflies, for example, the female is deſtitute of wings, while thoſe of the male are very large. The male and female of thoſe animals called *gall-inſects* bear no proportion to each other, either in ſize or in figure. They adhere for ſeveral months to the ſtems and branches of plants, ſhrubs, and trees, without any apparent movement. They have every appearance of galls, being of a ſpherical or oval figure, from which circumſtance they have received their denomination, and were long conſidered as vegetable ſubſtances deſtitute of every degree of animation. Reaumur, however, by a ſtrict examination of the changes they undergo, and of their internal ſtructure, diſcovered that they belong to the animal kingdom. He found that they contained thouſands of ſmall eggs, and that, from theſe eggs, ſmall animals were produced, which ran about with ſome quickneſs, and ſpread themſelves all over the tree or buſh. After ſome days, they attach themſelves to the ſtem and branches, remain immoveable, and gradually increaſe to their full dimenſions, when their bodies are found to contain numbers of eggs. As the perfect animal had no apparent motion, and yet multiplied its ſpecies, it was firſt thought to be an hermaphrodite of a ſingular kind, and that it was capable of producing without any foreign aid. But Reaumur diſcovered that they were impregnated by ſmall flies, and that theſe ſmall flies were male gall-inſects. The head, the body, the breaſt, and the ſix limbs of this fly, are of a deep red colour; and the wings, which are proportionally large, are white, bordered with a band of fine carmine red. In the month of April, he perceived numbers of theſe flies wandering about on the gall-inſects. He obſerved that they pierced the covering of the gall-inſects with a kind of ſting ſhaped like a needle. This circumſtance created a ſuſpicion that theſe flies were the males, and that this was their mode of impregnating the eggs of the female. To aſcertain this point, he opened a number of gall-inſects, which had no uncommon appearance, and, in ſome of them, he found the males, in

every

every ftage of their exiftence, till they pierced the external covering, came out in the form of perfect flies, and attached themfelves, as ufual, to the females. The glow-worm, an animal condemned to crawl perpetually on the furface of the earth, is a female; and the male, inftead of a reptile, is a fcarabaeus, or beetle, furnifhed with four wings. A fpecies of phofphorus, emitted from the body of the female, excites the attention of this apparently ftrange male, who darts down upon her, and actually enables her to continue the kind *. The female of another fpecies of beetle is a perfect reptile, and has not the fmalleft veftige of wings. But the male is a real beetle with four wings, and is fo difproportioned to the female in fize, that their junction fhould appear to be equally fingular as that of a ram with an elephant. With regard to the pucerons, or vine-fretters, the males are winged; but the females remain during life totally deftitute of wings. In fome fpecies of them, however, the females have wings, and thefe inftruments of motion are denied to the males. Between the fize of the male and female pucerons, there is likewife a remarkable difproportion. The males, particularly thofe which have no wings, are fo comparatively fmall, that they run about, like the male gall-infects, upon the backs of the females. While this exercife continues, which is often very long, the female remains almoft motionlefs. The more infenfibility and liftleffnefs fhown by the female, the male exhibits the greater ardour and agility. In this fituation he paffes whole days without taking any nourifhment.

In birds of prey, the females are larger, ftronger, fiercer, and more beautiful than the males. This fuperiority of ftrength and magnitude is conferred on the females, becaufe, in general, they are obliged to procure food both for themfelves and for their progeny. Vultures, however, are to be excepted; for the males are equal in

H h † fize,

* Reaumur. Oeuvres de Bonnet, tom. 2. p. 87. edit. 8vo.

ſize, if they do not exceed that of the females. In the gallinaceous tribe of birds, on the contrary, the males are larger, more beautiful, and more courageous, than the females. The peacock, the turkey, the pheaſant, and the dunghill cock, are remarkable examples. Dunghill cocks, eſpecially that kind of them which are called *game-cocks*, are the moſt intrepidly bold and high-ſpirited animals in the creation. Nothing but abſolute death can make them yield to an antagoniſt. In the domeſtic ſtate, at leaſt, this intrepidity, and this daring ſpirit, reſult from competition, and jealouſy of rivals. Game-cocks, to the diſgrace of humanity, are fed and trained with the moſt ſcrupulous attention. For what purpoſe? For the cruel amuſement and fortuitous emolument of gamblers.

That there are natural hermaphrodites, I have formerly mentioned. But, in man, dogs, cats, unnatural hermaphrodites, if they ever exiſt, are ſo rare, that the celebrated anatomiſt, Mr Hunter, declares he never ſaw a ſingle example. But, in the horſe, the aſs, black-cattle, and ſheep, he has ſeen many hermaphrodites. It is ſaid to be a known fact, that, when a cow brings forth two calves, one of them a male, and the other a female, the female is incapable of propagation, but that the male is a perfect animal. In England, a cow-calf brought forth with a bull-calf is denominated a *free martin*, and is as well known among farmers as either cow or bull. Mr Hunter remarks, that a cow-calf, brought forth in the ſituation above mentioned, may be either a free martin or a perfect female. 'For,' he remarks, 'I have reaſon to believe, that, in 'black cattle, ſuch a deviation may be produced without the cir- 'cumſtance of twins; and, even when there are twins, the one a 'male, the other a female, they may both have the organs of gene- 'ration perfectly formed *.' What is called a *free martin*, or imperfect

* Hunter's Obſervations on the Animal Oeconomy, p. 49.

perfect hermaphrodite, as far as obfervation has hitherto extended, is confined to black-cattle. The free martin has all the external characteriftics of a female calf. When animals of this defcription are preferved by farmers, it is not for the purpofe of propagation, but for yoking with the oxen, or fattening for the table. They neither breed, nor, what is curious, do they difcover the fmalleft inclination for the male, nor does the bull pay the leaft attention to them.

The free martin, in figure, refembles the ox, or fpayed heifer. It is confiderably larger than the bull or cow, and its horns are fimilar to thofe of the ox. 'The belly of the free martin,' fays Mr Hunter, 'is fimilar to that of an ox, having more refemblance to that of 'the cow than of the bull. Free martins are very fufceptible of 'growing fat with food. The flefh, like that of the ox, or fpayed 'heifer, is in common much finer in the fibre than either the bull 'or cow, and is fuppofed to exceed that of the ox or heifer in de'licacy of flavour, and bears a higher price at market *.' The Romans feem to have had fome knowledge of free martins, though they have not tranfmitted to us any peculiarities in the ftructure of thefe animals. With them, *taurus* was the generic name of the ox kind. They likewife mention *taurae*, by which, it is thought, they meant barren cows. Columella, when talking of cattle, fays, 'and, 'like the *taurae*, which occupy the place of *fertile* cows, fhould be 'rejected †.' Varro likewife informs us, that 'the cow which is '*barren* is called *taura*.'

Mr Hunter gives an anatomical defcription of three free martins, the moft perfect of which we fhall tranfcribe.

 '*Mr*

* Hunter's Obfervations on the Animal Oeconomy, p. 50. † Columella, lib. 6. cap. 22.

'*Mr Arbuthnot's Free Martin* *.

'The external parts were rather fmaller than in the cow. The 'vagina paffed on, as in the cow, to the opening of the urethra, 'and then it began to contract into a fmall canal, which paffed on 'to the divifion of the uterus into two horns; each horn paffed 'along the edge of the broad ligament laterally towards the ovaria. 'At the termination of thefe horns were placed both the ovaria 'and the tefticles; both were nearly of the fame fize, which was 'about as large as a fmall nutmeg. To the ovaria I could not find 'any Fallopian tube. To the tefticles were vafa deferentia; but 'they were imperfect. The left one did not come near the tefticle; 'the right one came clofe to it, but did not terminate in a body call-'ed the epididymis. They were both pervious, and opened into 'the vagina near the opening of the urethra. On the pofterior fur-'face of the bladder, or between the uterus and bladder, were the 'two bags called *veficulae feminales* in the male, but much fmaller 'than what they are in the bull: The ducts opened along with the 'vafa deferentia †.'

SECTION

* 'This animal was feven years old, had been often yoked with the oxen, at other 'times went with the cows and bull, but never fhowed any defires for either the one 'or the other.'

† Hunter's Obfervations on the Animal Oeconomy, p. 52.

SECTION II.

Of the Sexes of Plants.

WHEN an hypothefis, or theory, has obtained a general reception among even the enlightened part of mankind, it is extremely difficult to eradicate the prejudice, either by arguments or by facts. There is not a notion more generally adopted, than that vegetables have the diftinction of fexes, and that the influence of what is called the male is indifpenfibly neceffary to the fecundation of the female, or feed-bearing plant: A notion which I have long confidered as a ftriking example of the danger of rafhly yielding affent to the alluring feductions of analogical reafoning *.

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* The fubftance of the following facts, and reafoning, was delivered, above twenty years ago, in the Botanic Garden at Edinburgh, in prefence of the late worthy and learned Dr Hope, and his ftudents. Dr Hope, in order to excite induftry and attention in his pupils, appointed annually four of their number to give a lecture, or difcourfe, upon fome botanical fubject, which he prefcribed to them. To me the Profeffor affigned the Sexes of Plants, with the liberty of oppofing the doctrine of Linnaeus, and his own. Being at that time a very young man, and a ftrict believer in the fexual fyftem of plants, I willingly undertook the tafk, becaufe I thought I had the chance of fhowing fome little ingenuity in attempting to fhake a theory which I then imagined to be eftablifhed upon the firmeft bafis of fact and experiment. But, after

Every perfon who is acquainted with the fexual theory of vegetables, and with the arguments by which it is defended, muft acknowledge, that its principal fupport is derived from the many beautiful analogies which fubfift between plants and animals. Becaufe all animals were fuppofed to propagate by fexual embraces, and becaufe plants refembled animals in their growth, their nourifhment, their diffemination, and decay, it was therefore concluded, that all vegetables were either male, female, or hermaphrodite; and that fexual commerce was equally neceffary for the fecundation of the vegetable as of the animal tribes.

This analogy was plaufible, and feemed to beftow a fplendid uniformity on the conduct of Nature. But experiment, the only teft of natural truths, has totally annihilated this beautiful fabrick. The numberlefs fpecies of vine-fretters, of polypi, of millepedes, and of infufion animalcules, multiply, without having recourfe to the common laws of generation. Here, then, the analogy ftops; and, inftead of bringing aid to the fexualift, operates powerfully againft his favourite hypothefis. If many fpecies of animals are deftitute of all the endearments of love, what fhould induce us to fancy that the oak or the mufhroom enjoy thefe diftinguifhed privileges?

The analogy, befides, is frequently contradicted in the ordinary oeconomy of vegetables. It is univerfally allowed, for example, that, even in oviparous animals, the eggs can only be impregnated while they are in a gelatinous or mere embryo ftate. When farther advanced, their membranes, or fhells, acquire a confiftence fufficient to refift the male influence. But, among the vegetable tribes, every

after perufing Linnaeus's works, and many other books on the fubject, I was aftonifhed to find, that this theory was fupported neither by facts nor arguments, which could produce conviction even in the moft prejudiced minds. This difcourfe was afterwards publifhed in the firft edition of the Encyclopedia Britannica.

every circumftance is reverfed. In moft hermaphrodite plants, (I muft fpeak in the language of the fyftem), the feeds are not only not in a gelatinous ftate, but have acquired confiderable bulk and folidity, long before the pollen, or fuppofed fecundating duft, is thrown out of its capfules.

The fame remark is applicable to dioicous plants, or fuch as are barren and feed-bearing in different individuals. What conclufion is here to be drawn? Analogy fails; and facts contradict the analogy. The pollen of moft plants fheds after the feeds of their refpective fpecies are far advanced in fize and confiftence. If this pollen had the power of fecundating, it could feldom impregnate plants of its own fpecies; becaufe, when it is difcharged, the feeds are paft the proper feafon; but, by flying promifcuoufly abroad, this pollen might impregnate different fpecies which happened then to be in a fit condition for the reception of male influence. Confider the confequences of fuch an arrangement. Is not this to make Nature operate againft her own intentions? Nature intends that plants fhould multiply and perpetuate their kinds; but the fexual hypothefis makes her take the moft effectual meafures to prevent that intention, and to introduce univerfal anarchy among the vegetable tribes. Were this theory true, the whole vegetable kingdom, in a few years, would be utterly confounded: Inftead of a regular fucceffion of marked fpecies, the earth would be covered with monftrous productions, which no botanift could either recognife or unravel.

The propagation of plants by fuckers, flips, and cuttings, is a curious fact in the hiftory of vegetation. The ftrawberry is commonly raifed by flips taken from the old root, or by fuckers fent off from the plant. In either of thefe methods, the plants flourifh, and produce fruit. Many bulbous and eye-rooted plants, and moft ſhrubs and trees, may be propagated in the ſame manner. Where, it may be aſked, do theſe plants procure impregnation? That they grow, and produce fertile fruit, is undeniable; and yet, according to the ſexual hypotheſis, the pollen of the male is indiſpenſibly neceſſary to the ripening and fertilization of the fruit. By means of ſuckers, ſlips, cuttings, and layers, the whole globe might be ſpread over with vegetables, without the poſſibility of a ſingle impregnation.

Though the argument from analogy ſhould be inconcluſive, yet, ſay the ſexualiſts, we appeal to facts. I ſhall, therefore, give a ſhort view of the principal facts employed to ſupport the ſexual intercourſe of plants.

After what has been remarked, it will not be expected that I ſhould mention thoſe parts of Linnaeus's reaſoning which are derived from analogy. In many inſtances, he has puſhed analogy ſo far beyond all decent limits, that it becomes truly ridiculous. For example, he gravely tells us, 'That the calix repreſents the marriage *bed;* the corolla the *curtains;* the filaments the *ſpermatic veſſels;* the antherae the *teſtes;* the pollen the *male ſemen;* the ſtigma the extremity of the *female organ;* the ſtylus the *vagina;* the germen the *ovarium;* the pericarpium the *impregnated ovarium;* and the ſeeds the *eggs* *.'

The moſt plauſible fact in favour of the ſexual hypotheſis is derived from the culture of the date-bearing palm-tree. Haſſelquiſt †, and ſome other travellers, mention their having ſeen flowering branches of

* Sponſalia Plantarum, in Amoen. Acad. vol. 1. p. 103.

† Haſſelquiſt's Travels, p. 112. 416. Kempfer. Amoen. p. 706. Tournefort Iſag. p. 69.

of male trees fixed to the females by Arabian gardeners, who alledged, that, unlefs this operation were performed, their dates would neither be good nor plentiful. This practice can boaft of an antiquity long prior to the notion of fexes in plants. How it came to be introduced, it is of little importance to inquire. We know that the cuftom is ftill faid to prevail: But we likewife know, that there is not an authentic fact which fhows any connection between the *practice* and the *event*, though that be an effential ingredient in the controverfy. The eaftern nations are famous for introducing fuperftition into every part of their oeconomy; and it is equally difficult to account for their manners as for their culture of palm-trees.

Mylius's letter to Dr Watfon, recorded in the Philofophical Tranfactions, is an attempt to remove this difficulty, and to fhow a neceffary connection between the male and female palm. Mylius writes to his correfpondent, 'That a female palm-tree grew many years 'in the garden belonging to the Royal Academy at Berlin, without 'producing any ripe or fertile fruit; that a male branch, with its 'flowers in full blow, was brought from Leipfic, about twenty German miles from Berlin, and fufpended over the female tree. The 'refult was, that the female yielded, the firft year, 100 ripe dates. 'The fame experiment being repeated the following year, 2000 ripe 'fruit were produced.'

Not to call Mylius's veracity in queftion, the experiment is both inconclufive and defective. Berlin is not the climate of palm-trees. The tree, he informs us, bore flowers and fruit for thirty years before the trial was made; but the fruit, it is faid, never came to maturity. Plants feldom produce ripe fruit in a climate not adapted to their nature, until they have grown there a long time. Mylius's palm-tree had carried unripe fruit for thirty years. According to the ufual courfe of exotic plants, therefore, it is natural to think, that, like the American aloe, the tree, during all this time, was making gradual advances toward perfection; that, when the male branch happened to be suspended over the female, the plant had arrived at the highest degree of maturity it could ever acquire in the climate of Berlin; and, of course, that the accidental circumstance of suspending the male branch over it, at this critical period, might give rise to the deception of attributing the ripening of the fruit to the presence of the male branch. The production of 100 ripe fruit only the first year, and 2000 the second, is a strong corroboration of this account of the matter. At any rate, the experiment is exceedingly defective and unsatisfactory. To convince any man that the fertility of this tree was solely owing to some impregnating virtue communicated to it by the male, a branch should have been suspended over the female one year, omitted the next, and so on alternately for a succession of seasons, or, as the sexualists would express it, giving her a husband one year, and denying her that gratification the next. After treating the female in this manner, if it had uniformly happened, that the fruit ripened every year the male branch was suspended, and that none came to maturity when that operation was omitted, then there would have been some foundation for supposing a connection between the ripening of the fruit and the presence of the male branch. But, as this necessary precaution was omitted, the experiment is incomplete, and the conclusion drawn from it precipitate and unphilosophic.

In accounting for the fecundity of all the *dioicous* * and *monoecious* † plants, the sexualists have recourse to the aid of the winds, and of insects. They betake themselves to this strange refuge, in order

* Plants which have the male character in one individual, and the female in another.

† Plants which have both the male and female characters in the same individual.

order to explain the manner in which female plants, when ſituated at a diſtance from males, are impregnated. Some of them, as Kalm, and others, are perfectly ſatisfied with this ſuppoſed aerial commerce of vegetables, even when the males are ten, fifteen, or twenty miles diſtant from the females! Here, it may be remarked, that the multiplication of ſpecies is one of the moſt important laws of Nature. All the laws of Nature are fixed, ſteady, and uniform, in their operation: None of their effects are abandoned to thoſe uncertainties which neceſſarily reſult from chance, or from any fortuitous train of circumſtances. But, is there any thing, in northern climates at leaſt, more deſultory and capricious than the direction and motion of the winds? Can we form a conception of any thing more caſual and uncertain than the wayward paths of inſects? The very ſuppoſition, therefore, that Nature has expoſed the fertility of a tenth part of the whole vegetable kingdom, and many of them, too, plants of the utmoſt importance to man, and other animals, to ſuch accidental cauſes, is repugnant to every idea of ſound philoſophy. Beſides, the reverſe has been proved by Dr Alſton, Camerarius, and Tournefort. Theſe gentlemen reared female plants of the ſpinage and hemp in ſuch ſituations, and with ſuch ſcrupulous precautions, to prevent any ſuppoſed impregnation by means of the wind, or of inſects, that it is difficult to conceive the poſſibility of any communication between the males and females. Theſe females, however, produced fertile ſeeds in the greateſt abundance.

Since theſe experiments were made, it has been diſcovered, that male flowers are ſometimes found lurking on the female plants of the ſpinage and hemp: And this diſcovery the ſexualiſts think ſufficient to account for the ſucceſs of Dr Alſton's experiments. But, inſtead of ſolving the difficulty, this circumſtance ſeems to involve it in ſtill deeper obſcurity: For, that the pollen iſſuing from the antherae of a male flower or two ſhould riſe, fall, and turn round in every direction, ſo as to light preciſely on the ſtigmata of all the ſuperior, inferior, and circumjacent female flowers, appears to exceed the common powers of human faith. Beſides, this circumſtance would ſeem to indicate, that there is no ſteadineſs in what is called *vegetable ſexes*. We are even told, that trees, which had continued many years under the character of females, but, from ſome ſtrange metamorphoſis, had ſuddenly dropped their female forms, and aſſumed the more robuſt features peculiar to the male part of the creation!

It was hinted above, that all the dioicous, monoecious, as well as moſt of the hermaphrodite flowers, being impregnated by means of the wind, ſeemed not to accord with the rules of philoſophizing; we ſhall now examine that doctrine more cloſely.

The pollen is allowed to be too large to get admiſſion into the ſtigmata, though laid upon them with the greateſt dexterity. This difficulty the ſexualiſts imagine to be removed, when they tell us, that moiſture makes the pollen ſplit, and diſcharge a ſubtile aura, and that this aura impregnates the ſeeds. But, though the pollen ſhould explode by the application of moiſture, and diſcharge a ſubtile aura, this exploſion could never effect the purpoſes of impregnation: For, when the pollen was lying on the ſtigma, the aura muſt neceſſarily blow off, inſtead of being abſorbed by that part of the plant. Is not the ſuppoſition ſingular, and even contradictory, that a plant ſhould be impregnated by a ſubſtance forcibly blown away from the female?

This reaſoning proceeds upon the admiſſion, that the pollen is laid with dexterity upon the ſtigma. But it will receive additional force, when I defy all the naturaliſts in the univerſe to produce an inſtance of a ſingle grain of pollen being ever ſeen on any part of a female

female plant, even when at no great diftance from a male, far lefs upon the ftigmata of each feparate flower. Granting, however, the pollen to be carried off from the male by the wind, yet, as the fuppofed fecundating aura it contains is much lighter than air, and is difcharged by the flighteft moifture, it can never fall down upon the diftant females, but muft rife and diffipate in the higher regions of the atmofphere. It may alfo be difcharged by the application of rain or dews before the pollen is carried off by the wind from the male flowers: And, if the winds blow in a direction contrary to the fituation of the female plants for a few critical hours, the females muft be rendered barren, at leaft for a feafon.

It is an eftablifhed fact, that coleworts, turnips, &c. when growing in gardens, fometimes produce new varieties. Thefe varieties the fexualifts uniformly hold up as inftances of hybrids, or mongrels, from fortuitous commixtures of different males and females. This conclufion, however, feems to be precipitate. It is well known to nurferymen and gardeners, that, from feeds of the fame individual plants, varieties fometimes appear. If thefe varieties chance to have any qualities fuperior in value to the original plants, their feeds, fhoots, or flips, are collected, and the new kind is propagated with diligence. That the beauty of flowers, and the magnitude and flavour of fruits are improveable by particular modes of culture, and even by unknown accidents, is an undeniable truth: That thefe improved qualities, in whatever manner procured, continue in the kind, unlefs allowed to degenerate by negligence, is not lefs true. But there is nothing fo wonderful in thefe phenomena as to require the moft unbounded ftretches of fancy to account for them. Are not the beauty, ftrength, and magnitude of animals, equally improveable by culture? Does not an ox, tranfported from the comparatively barren mountains of Scotland, to the rich paftures of Yorkfhire, affume qualities very different from thofe he originally poffeffed?

Why,

Why, then, ſhould an inconſiderable change in the conſtitution of a colewort, or a turnip, excite ſurpriſe ? Plants are liable to be diverſified by numberleſs accidents. Perpetually fixed to the ſame local ſituation, they muſt receive, indiſcriminately, ſuch nouriſhment as is tranſmitted to them by the earth and air. When different kinds happen to grow very near each other, and, as they have not the choice of rejecting ſuch food as is preſented to them, may not exudations from the one be abſorbed by the roots of the other? May not the matter which tranſpires ſo copiouſly from the leaves and flowers of one plant be conveyed to, and abſorbed by, thoſe of a different kind ? And may not this foreign nouriſhment occaſionally introduce ſome changes in the colour, texture, or flavour, of the leaves, flowers, or fruit? Nay, is it not reaſonable to ſuppoſe, that ſolutions of various mineral ſubſtances, the action of particular manures, and a thouſand other circumſtances, may often induce ſuch changes? Why, then, ſhould we have recourſe to unnatural and ſtrained analogies, when the phenomena may be ſolved upon the principles of ſound philoſophy?

The learned Dr Hope, late Profeſſor of Botany in the Univerſity of Edinburgh, who was a ſtrenuous ſupporter of vegetable ſexes, thought he had almoſt eſtabliſhed the theory by the following experiment upon the lychnis dioica, of which two varieties are natives of Scotland, the one bearing white, and the other red flowers. The Doctor, about twelve years ago, raiſed a white female and a red male under the ſame glaſs-bell, which was ſunk ſo far in the ſoil as to prevent all communication with other vegetables. The bell terminated in a tube, which, for the occaſional introduction of a little freſh air, was ſtuffed with moſs. The ſeeds of the white female were ſown next ſeaſon ; and, inſtead of white, the plants produced red flowers, in conſequence, it was imagined, of the influence of the male upon the female. He likewiſe aſſerted, that the red kind,

when

when left to Nature, never brought forth white flowers, nor the white kind red flowers.

Upon this experiment we have to remark, 1. That nothing is more dangerous, or more fallacious in philosophy, than the assumption of general positions without an accurate investigation. The Doctor advanced, for example, that the red and the white lychnis, when in a natural state, never change their colours. This position is neither capable of admission nor denial; because no experiment, nor inquiry, seems ever to have been made on the subject: Yet it is assumed as a premise to the conclusion, that the change of the white into a red lychnis was occasioned by the influence of the red male upon the white female.

2. That hybrids, or mules, uniformly participate of both the species or varieties by which they are engendered. A jack-ass and mare never produce a simple ass or horse, but a mule, or mixture of the two. It should seem, however, that this red lychnis transfused its own individual qualities, without allowing a single particle of the female to appear. This is contrary to every analogy. If the change had originated from sexual commixture, the progeny ought not to have been completely red, but pied, or a mixture of red and white. To whatever cause, therefore, this change may be attributed, it can never be ascribed to any thing analogous to generation.

3. That colour is a delicate and fluctuating quality. It depends so much on light, air, health, and perhaps some unknown causes, that botanists, with great propriety, have rejected it as a specific character. Suspecting that causes of this nature might change the colour of the white lychnis under consideration, I examined the condition of some plants then subjected to the same trials in our Botanic Garden. The flowers both of the red and white lychnis

were then in full blow under the bell, the glaſs of which was thick, and of a darker green than our common beer-bottles. The light, of courſe, tranſmitted to the plants was lurid and obſcure. They were alſo deprived of a free circulation of air. Under theſe unnatural circumſtances, the plants had a ſickly aſpect. The flowers of the red variety, inſtead of a vivid red, were almoſt perfectly white. Here we have nearly an equal change made upon the ſame plant, without the poſſibility of its being effected by the intercourſe of ſexes. If plants are thus deprived of proper light and air, it cannot be ſurpriſing to ſee changes produced in the colour of their immediate deſcendents. The contaminated air eſcaping from the plants themſelves, and from the ſoil under the bell, may be ſufficient to produce this effect. I formerly mentioned, that the colour, and other qualities of plants growing near each other, may be changed by abſorbing the matter of tranſpiration and exudation. The argument is applicable with peculiar force to plants impriſoned ſo cloſely, and having ſo little acceſs to freſh air. In this ſituation, they muſt, of neceſſity, feed upon each other. Confine a man and a woman for years in a ſmall ill-aired cell, and obſerve their aſpect, and that of their progeny. Their appearance will be very different from that of children produced by healthy parents, and enjoying the benefits of the ſun's rays, and of the open air.

4. That, independently of all theſe arguments, the experiment is incomplete. Even on the ſuppoſition of the exiſtence of ſexes in plants, the concluſion drawn from it cannot be admitted. The ſame change, for inſtance, might have happened, if, inſtead of a white female and red male, a white female had been impriſoned with a red female. In this caſe there could be no commixture of ſexes; and yet, it is highly probable, that both would have ripened their ſeeds, and that theſe ſeeds would have produced plants differently coloured from the ſame varieties growing in a natural ſtate. Till theſe indiſpenſible

penſible parts of the experiment, therefore, be tried, nothing can be concluded in favour of the ſexual ſyſtem.

5. That flowers growing from the ſame root, fruits upon the ſame tree, or raiſed from ſeeds of the ſame individual plant, often vary in colour, ſize, figure, and texture. Theſe varieties are apparent to the moſt ſuperficial obſervers; but they can never, with any degree of propriety, be aſcribed to the influence of ſex. The cauſes of ſuch variations are rather to be looked for in the expoſure of the plants with regard to light and air, the nature of the ſoil, the mode of culture, accidental injuries from dews, from electrical fire, from the poiſon or wounds of inſects, and from the abſorption of mineral ſolutions. In a word, if we are to hope for an explanation of theſe, and other minute changes in the appearances of plants, recourſe muſt be had to chemical and philoſophical principles, and not to an hypothetical commerce of ſexes.

The diſcourſe was concluded with the following ſentiment:—But I aim not at complete refutation; for experiments are ſtill to be made. I only wiſh to render the ſexual commerce of plants ſuſpicious, that the minds of men may be freed from the fetters of a ſyſtem, which has, perhaps, too long received the general aſſent of Europe; and that the oeconomy of the vegetable kingdom may again be open to impartial inveſtigation.

To remove the poſſibility of male influence being conveyed by means of the wind, or of inſects, about ten or twelve years ago, I thought, if a female plant could ripen her ſeeds within doors during the winter, the experiment would infallibly determine the controverſy. With this view, I confined a female lychnis, which is a native plant of this country, and gave her ſuch a degree of heat as made her produce flowers three months before any male flowers of the ſame ſpecies were blown in Britain. The flowers and the young ſeed had every appearance of health and vigour. But the plant itſelf, as uſually happens to vegetables when forced to grow in unnatural ſituations, was feeble, ſlender, and double the common length it acquires in the fields. I waited the event. My expectations, however, were diſappointed; for the flowers dropped long before the ſeeds were ripened. The plant was kept three years in the ſame ſituation; but ſtill the flowers dropped, and no ripe ſeeds were produced. As the health of plants, like that of animals, depends upon many circumſtances, as expoſure to the open air, to light, to the agitations of the wind, which to them anſwers the invigorating purpoſe of exerciſe, to nocturnal dews, to natural rains, inſtead of artificial waterings, &c. I reſolved to place the female lychnis in a ſituation where ſhe might enjoy all theſe advantages, and at the ſame time be removed from every ſuſpicion of a connection with male influence. For this purpoſe, I applied to my learned and ingenious friend Dr Daniel Rutherford, now Profeſſor of Botany in the Univerſity of Edinburgh, who, at that time, had a ſmall garden, or rather a little area, in the heart of the city, which was ſurrounded with houſes of five and ſix ſtories high, and diſtant from any male lychnis about an Engliſh mile. Dr Rutherford received this female lychnis into his garden. The firſt ſummer after her admiſſion, being enfeebled by her former three years confinement, ſhe dropped her flowers, without producing fertile ſeeds. During three or four ſucceeding years, however, ſhe remained in the ſame ſituation; and ſhe not only ripened her ſeeds, but theſe ſeeds vegetated, without the poſſibility of any male impregnation; for the Doctor, after the young plants were in a ſtate of diſcrimination, uniformly extirpated all the males, and never could diſcover the veſtige of a ſingle male upon the female plants. Her female progeny, however, continued to bear fertile ſeeds for ſeveral ſucceſſive generations. If, after this, and ſome experiments formerly mentioned, any ſexualiſt chooſes to have recourſe to the wind;

wind, and to infects, he may enjoy his theory; but few men of penetration will join him in opinion.

But, if these facts and reasonings should not be sufficient to convince every believer in the sexual system of plants that the hypothesis has no foundation in Nature, Spalanzani, a late ingenious Italian naturalist, has, by a number of experiments, removed the possibility of any rational doubt on the subject.

Spalanzani, in order to make a complete investigation of this subject, performed a number of experiments on what are called *hermaphrodite*, *monoecious*, and *dioicous* plants.

Hermaphrodite plants comprehend all those which have stamina and pistils, or the male and female organs, in the same flowers. To discover whether the pollen had any influence upon the fertility of the seeds, Spalanzani forced open the petals, or flower-leaves, some time before they began to expand. He then cut off all the stamina, or male parts, before the supposed foecundating dust was ripe, leaving the female part to its fate. The result was, that, in many of the plants, the seeds did not ripen, or even acquire their full size; in others, they grew to the natural size; but, after being committed to the ground, they did not germinate. Above thirty years ago, a similar set of experiments were made, in the Botanic Garden at Edinburgh, by the late Dr Alston, the then Professor of Botany. But, whether Dr Alston's experiments were performed with greater dexterity than those of Spalanzani, it is impossible to determine. The event, however, was the reverse; for Dr Alston's plants, which were treated in the same manner with those of Spalanzani, not only ripened their seeds, but these seeds, when sown, were found to be as fertile as if no such operation had been performed. But no experiments of this kind can be made with any degree of certainty upon hermaphrodite plants; becaufe they are impracticable, without wounding and injuring the tender flowers. By forcing open the petals fome days before they would naturally unfold, the interior parts of the flowers are prematurely expofed to the action of the air, of dews, and of the fun's rays. Befides, no man can determine what changes the young feeds may undergo, what injury they may fuffer, by an unnatural deprivation of the ftamina. In every flower treated in this rough manner, an extravafation of fap muft unavoidably be produced. If a pregnant animal is wounded, and in a part too fo intimately connected with the foetus, what reafon have we to expect a fertile and well-proportioned offspring?

Spalanzani next proceeded to trials on the monoecious plants, or thofe which bear both male and female flowers feparately on the fame individual. In fpring 1777, he fowed two fpecies of the pumpion, which belong to this divifion of plants, in a fituation removed from every fufpicion of foreign connection by means of the wind or of infects. 'In the beginning of June,' fays he, 'two individuals, for I had ordered two only to be raifed, were juft beginning 'to put forth a few flower-buds towards the bottom of the ftalk. 'At this early period, the male flowers may be eafily diftinguifhed 'from the female. The former, alfo denominated *barren* by botanifts, have a flender ftalk; while the ftalk of the latter, where it 'joins the calyx, forms a tumor, confifting of the immature fruit. 'I paid daily vifits to thefe two individuals, and very carefully 'watched the progrefs of both forts of flowers. That there might 'be no fufpicion of the pollen exerting any influence upon the females, the males were deftroyed at their firft appearance. As fruit, 'when a fmall quantity only is left upon a plant, is fooner ripe, 'and grows to a larger fize, becaufe it receives a greater quantity of 'nutritious juice, I left on each of my two individuals two flowers 'only. The buds that made their appearance afterwards were ta-

'ken

'ken away, along with the male flowers. Meanwhile my four 'gourds grew rapidly. Finding that, towards the middle of Sep- 'tember, they had attained the ufual full fize, I gathered one, in 'order to infpect the internal parts. The flefh was too foft, becaufe 'the fruit was not thoroughly ripe; but, in colour, ftructure, and 'tafte, it refembled fruit produced by plants which had their male 'flowers.—The feeds were in great number, and, as well internally 'as externally, were perfectly formed.—At the end of the month, 'the other three gourds were quite ripe. I therefore gathered them, 'and put the feeds of each into a feparate box, that I might be able 'to examine them at pleafure. The lobes filled the whole infide of 'the feeds, and had all the characters of perfect maturity.

'Thus far,' continues our author, 'there is a perfect agreement 'with the obfervations made on the feeds of fome hermaphrodite 'plants, which feemed, notwithftanding they were deprived of the 'efficacy of the pollen, to have acquired the fame degree of per- 'fection as thofe impregnated in the ufual manner. But, as they 'did not grow, however perfect they might be in appearance, be- 'caufe they had not been vivified by the pollen, I imagined, that, 'for the fame reafon, the feeds of my three gourds would not grow. 'It was, however, proper to make the experiment. I therefore 'dried one hundred and fifty in the fun, and afterwards planted 'them in three pots, fifty in each, taken from feparate gourds. But 'the latenefs of the feafon, it being the 10th of October, the con- 'ftant rain, and the coolnefs occafioned by it, circumftances unfa- 'vourable to vegetation, obliged me to place my pots in a ftove, 'which, though it was not heated, was kept warm by a contiguous 'chimney. *The event did not by any means correfpond to my expec- 'tation.* I took it for *granted*, that *none* of the feeds would *germi- 'nate*; and yet they *almoft all came up* very well *.'

Here

* Spalanzani's Differtations, vol. 2. p. 276. &c.

Here it is pleaſant to obſerve candour and fair experiment triumphing over deep prejudice. From the above, and many other paſſages, it is evident that Spalanzani was a keen ſexualiſt, and that he expected his experiments, inſtead of overthrowing, would confirm his faith; but, like a true philoſopher, he candidly, though with reluctance, unhinges his favourite opinion.

'I reſerved the remainder of the ſeeds,' continues Spalanzani, 'for another experiment to be made the following ſpring. Before 'it can be aſſerted that fructification has been complete, it is neceſ- 'ſary, according to the determination of botaniſts, not only that the 'ſeeds ſhould grow, but that they ſhould alſo be capable of bringing 'productive ſeeds, or, in other words, of perpetuating the ſpecies. 'That I might learn whether the ſeeds of my three gourds enjoyed 'this prerogative, I cauſed ſome of them to be planted in the ſame 'place in May 1778; and, when they were grown to ſome ſize, 'they were, as in the foregoing experiment, carefully ſtripped of all 'their male flowers, one female flower only being left on each in- 'dividual. Theſe flowers were furniſhed with ſmall gourds, which 'grew ripe towards the beginning of autumn, and the ſeeds they 'produced grew juſt as well as the former *.'

With regard to dioicous plants, or thoſe which produce male flowers on one individual and female flowers on another, they are by far the moſt unexceptionable ſubjects for determining the exiſtence or non-exiſtence of ſexes in plants. Accordingly, Bonnet, Fourgeroux, and Spalanzani, &c. about the year 1770, placed female plants of this deſcription in ſituations ſo ſtrictly guarded againſt the poſſibility of foecundating duſt being conveyed to the females either by the air or by inſects, that the ſuppoſition of male influence baffles

* Spalanzani's Diſſertations, vol. 2. p. 278.

baffles all the powers of imagination. Thefe females, however, uniformly produced ripe feeds; and thefe feeds were as prolific as if they had been furrounded with males.

From the facts and arguments above related, and many others which might be adduced, it appears, that this beautiful theory, derived from a miftaken analogy, has no foundation in Nature. I would not have dwelt fo long on this fubject, if I had not fincerely wifhed that the minds of men might be emancipated from the fetters of a fyftem which has too long received the almoft univerfal affent of the literary world; and that the oeconomy of the vegetable kingdom may again be open to impartial inquiries.

CHAP.

CHAPTER X.

Of the Puberty of Animals.

THE puberty of animals commences at that period of their exiſtence when Nature endows them with the power of multiplying the ſpecies. This period is as various as the different tribes of animals. In ſome it arrives ſooner, in others later; but, in every animal, it is accompanied with ſome remarkable changes in conſtitution and affections. From infancy to puberty there is a gradual increaſe of ſize; but, immediately after that period, in both ſexes, the growth of the body makes a ſudden ſpring, and acquires redoubled ſtrength and activity. The growth of animals, however, does not always ſtop at the age of puberty. Men, quadrupeds, and fiſhes, continue to grow for ſome time after their capacity of multiplying. But moſt birds and inſects ſeem to acquire their full dimenſions before they arrive at the age of puberty.

Before puberty, the voice of a man, like that of a woman, is ſhrill and feeble. But, after that period, it becomes rough and ſtrong. This effect is produced by ſome unaccountable and ſudden change in the organs of ſpeech, which is not confined to the human ſpecies; for the voice of a horſe or a bull is deeper after than before puberty.

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In eunuchs, no ſuch alteration of voice is to be obſerved; for their voice, though ſhrill and piercing, can never produce a low or deep note. At this period, too, that diſtinguiſhing characteriſtic of man, the beard, begins to appear, together with other external and internal changes, which it is unneceſſary to relate. But eunuchs are totally deſtitute of beards. Theſe two facts indicate a connection which merits the attention of philoſophers.

With regard to the female ſex, they are by no means exempted from conſtitutional changes when they arrive at the age of puberty. The alteration in the tone of their voice, if it does happen, is hardly perceptible. Neither are their faces deformed by a beard, which, according to our preſent ideas, would have a diſguſting effect. At this period, however, their mammae ſwell, and a periodical evacuation takes place, which produces wonderful revolutions in their conſtitution and affections. In both ſexes, the mental changes are not leſs remarkable than the corporeal. The powers of the mind expand, the force of genius is felt, and very different objects ſolicit attention: Inſtead of puerile amuſements, ambition, a warm and unaffected friendſhip, a generoſity and unſuſpicious demeanour, both in words and actions, are the almoſt univerſal characteriſtics of this period of human life. I mention it with pleaſure, that, as far as my obſervation extends, in youth, unleſs they are corrupted by example, by neglect, or by other cauſes, all men are honeſt, friendly, generous, and humane. If this remark be true, Nature is fully exculpated. But, when a young man enters into the buſineſs of life, his candour and ingenuouſneſs ſoon meet with a ſhock. This is the painful reverſe. Inſtead of liberality and integrity of conduct, he has to encounter with ſelfiſhneſs, chicane, and too often with direct villany. This unhappy diſcovery turns his thoughts into a different current, contracts the noble openneſs of his heart, renders him ſuſpicious and guarded, and, if he ſhall chance to retain his integrity, he is obliged to aſſume, at leaſt, the appearance of jealouſy and deceit. I by no means intend this to be the univerſal character of mankind; I only lament that it is too general.

In every race of mankind of which we have any knowledge, the females arrive ſooner at puberty than the males. But the age of puberty differs in different countries. This difference ſeems to originate from two cauſes, the temperature of the climate, and the quality of the food. Children of citizens, and of opulent parents, who are fed with rich and nouriſhing victuals, arrive ſooner at this ſtate. Children, on the contrary, brought up in the country, or whoſe parents are poor, require two or three years longer; becauſe their food is not only coarſe, but too ſparingly given. In the ſouthern regions of Europe, and in large cities, the females arrive at puberty about the age of twelve, and the males about fourteen. But, in northern climates, and in the country, girls hardly come to maturity till they are fourteen, and boys not before ſixteen. In the warmeſt regions of Aſia, Africa, and America, the age of puberty in females commences at ten, and ſometimes at nine.

After puberty, the Count de Buffon remarks, 'marriage is the 'natural ſtate of man. A man ought to have but one wife, and a 'woman but one huſband. This is the law of Nature; for the 'number of females is nearly equal to that of the males. Such laws 'as have been enacted in oppoſition to this natural principle, have 'originated ſolely from tyranny and ignorance. Reaſon, humanity, 'and juſtice, revolt againſt thoſe odious ſeraglios, in which the liberty 'and the affections of many women are ſacrificed to the brutal 'paſſion of a ſingle man. Does this unnatural pre-eminence render 'thoſe tyrants of the human race more happy? No! Surrounded 'with eunuchs, and with women who are uſeleſs to themſelves and

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'to other men, they are tormented with the conftant appearance of 'that accumulated load of mifery they have created.'

All animals, as well as thofe of the human fpecies, undergo, at the age of puberty, fimilar changes in the form of their bodies, and in the difpofitions of their minds. From mild, placid, and gentle, they become bold, reftlefs, and ungovernable. Their bodies are then, in ftrength and fymmetry, perfectly accommodated to the new fentiments which Nature, for wife purpofes, excites in their minds. In the deer kind, the horns of the males appear not till they are fit for multiplying the fpecies. At this period, the creft, the wattles, and the plumage of the male gallinaceous birds acquire additional beauty, and their courage and ftrength are greatly augmented. The pigeon, inftead of being querulous, timid, and voracious, whenever the age of puberty arrives, feels emotions of a very different kind. Confcious of the new vigour he has acquired, he affumes a bold and important air. He ftruts about with a majeftic pride, and immediately addreffes, with all the gaiety of a lover, fome favourite female, whom he follicits with the moft affiduous gallantry and attention. After the coy female gives her affent, their after conduct exhibits fuch a mutual and ardent affection, and fuch a conftant fidelity, as afford no inconfiderable pattern to the human fpecies.

With regard to fifhes, we are totally ignorant of the periods when the different tribes of them acquire the power of multiplying. From the element they inhabit, from the rapidity of their motions, and from their defultory and wandering mode of living, we are equally ignorant of many other important parts of their oeconomy and manners. This continues to be an ample field for future inveftigation, and highly worthy of the attention of naturalifts.

The oeconomy and manners of infects are more open to infpection. Thofe of the winged tribes undergo many changes, both in figure and ftructure, before they arrive at the age of puberty. They firft efcape from the eggs in the form of minute caterpillars. In this ftate they are exceedingly voracious, and grow with rapidity to their full fize; but they are deftitute both of the power and of the organs neceffary for the multiplication of the fpecies. They are next transformed into chryfalids: In this ftate, their bodies are covered with a kind of cruft or fhell, from which the animals have again to efcape, as from a fecond egg. In this imprifoned condition, they remain during a longer or fhorter period, according to the fpecies, or to the feafon of the year in which they are transformed. After their transformation into flies, they burft this cruft or fhell, and appear in the form of flies, furnifhed with wings, legs, feelers, &c. of all which they were deftitute in their former ftate. When transformed into flies, caterpillars have arrived at the age of puberty. They are now perfect animals, and endowed with the faculty of tranfmitting a numerous progeny to pofterity.

CHAPTER XI.

Of Love.

THE great intention of Nature, in endowing almoſt every animal with a ſexual attachment, is the multiplication and continuation of the reſpective ſpecies. But, with regard to man, and, in an inferior degree, to all pairing animals, love is the ſource of many other ſocial and important advantages. Love, or a ſtrong affection for a particular woman, is to young men, perhaps, one of the greateſt incentives to virtue and propriety of conduct. In northern countries, it ſeldom riſes to that degree of frenzy, which, in warmer climates, not only engroſſes the whole attention, but often totally unhinges the powers of the mind. In northern regions, however, it occupies more gently the imagination, gives a chearfulneſs and alacrity to the buſineſs or ſtudies of life, and, if reciprocal, diffuſes over the mind and body a placid happineſs, and a tranquillity of diſpoſition, which greatly contribute to the health and vigour of both. A young man in love thinks that the eyes of his favourite continually behold him. Through this amiable medium he views all his actions, and even his thoughts. His affection and veneration are ſo great, that he is, in ſome meaſure, deterred from regarding any other woman, and, what is of more importance, from indulging any looſe or

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irregular appetite. The difpofitions and affections of the female are the fame with thofe of the male. Her attention is completely engroffed; and fhe never thinks or dreams of any man, but of him who is the object of her affection. A young man and a young woman in love exhibit the moft innocent and the moft amiable picture of human nature. Actuated by no interefted motives, and regardlefs of future contingencies, they obey the fupreme command of Nature. How much is it to be lamented, that, from the cruel, but perhaps unavoidable inftitutions and cuftoms of civil focieties, it is fo often not only prudent, but neceffary, to check, and even to overcome, this powerful law of Nature?

Many are the advantages that mankind derive from fociety and regular governments, and we fhould chearfully fubmit to thofe hardfhips and inconveniencies to which they give rife. But every man, however fubmiffive to the laws of his country, muft regret that neceffity which makes them oppofe any of the laws of Nature, and efpecially the almoft irrefiftible law of love.

In the prefent ftate of fociety, it muft be acknowledged, early marriages, among people in the ordinary and dependent ranks of life, are extremely hazardous. When both parties are induftrious and oeconomical, fuch marriages are not only the moft natural, but are productive of the greateft happinefs and cordiality. But the reverfe is dreadful! Children, ftraitened circumftances, refentment of parents, whether real or affected, too often produce all the complicated miferies to which mankind, in their loweft ftate of degradation, can be fubjected. Among this order of men, therefore, it is of the higheft importance that the law of Nature fhould yield, for fome time at leaft, to the inftitutions of fociety, and to thofe prudential motives which parents learn from experience to be ingredients effential to the comfort and happinefs of life.

Men

Men of fortune and of opulence have it in their power to obey the laws of Nature and of love; and ſome examples, though few in number occaſionally happen of rich men acting a diſintereſted part in their matrimonial engagements. Inſtead of following the dictates of Nature, many men of fortune and independence, diſregarding the high privilege they enjoy, ſacrifice their taſte, their paſſion, and often their happineſs during life, at the ſhrine of Gold. To accompliſh this ſordid end, they often embrace deformity, diſeaſe, ignorance, peeviſhneſs, and every thing that is diſguſting to human nature. Let ſuch individuals ſuffer their puniſhment. But what are the conſequences to the public? Men of rank, in all nations and governments, not only regulate, in a great meaſure, the manners of their inferiors, but are the natural guardians of the ſtate. For theſe important purpoſes, their minds ſhould be noble, generous, and bold; and their bodies ſhould be ſtrong, maſculine, fit to encounter the fatigues of war, and to repel every hoſtile aſſault that may be made upon their country. But, when men of this deſcription, whatever be their motives, intermarry with weak, deformed, puny, or diſeaſed females, their progeny muſt of neceſſity degenerate. The ſtrength, beauty, and ſymmetry of their anceſtors are, perhaps, for ever loſt. What is ſtill more to be regretted, debility of body is almoſt univerſally accompanied with weakneſs of mind. Thus, by the avarice, ambition, or inattention, of one individual, a noble and generous race is completely deſtroyed. By reverſing this conduct, it is true, the breed may again be mended; but, to repair a ſingle breach, many generations, endowed with prudence and circumſpection, will be requiſite. A ſucceſſive degeneration, however, is an infallible conſequence of imprudent or interreſted marriages of this kind. One puny race may for ſome time be ſucceeded by another, till at laſt their conſtitutions become ſo feeble that the animals loſe the faculty of multiplying their ſpecies. This gradual degeneration is one great cauſe of the total extinction of conſpicuous and noble families. That it ſhould be ſo, is a wiſe and beneficent inſtitution of Nature; for, if ſuch debilitated races were continued, a univerſal degeneration would ſoon take place, and mankind would be unable to perform the duties, or to undergo the labours of life. Nature firſt chaſtiſes, and at laſt extirpates, all thoſe who act contrary to her eſtabliſhed laws.

Beſide the pleaſures reſulting from ſociety, and from mutual attachment in man, and in pairing animals, the natural love of offſpring is a ſource of the moſt engaging endearments. The innocence and helpleſs condition of infants call forth our pity and protection. When a little farther advanced, their beauty, their ſmiles, and their ſprightlineſs, excite the moſt agreeable emotions. In their progreſs from infancy to manhood, we obſerve with pleaſure the unfolding of their mental powers. They imitate our actions long before they can expreſs their deſires, or their wants, by language. Their attempts in the acquiſition of language are extremely curious and amuſing. Their firſt ſyſtem of grammar conſiſts entirely of ſubſtantive nouns. It is long before they learn the uſe of adjectives or of copulatives, and ſtill longer before they employ the verb. Their ſpeeches are ſhort, aukward, and blundering; but they are animated, and uttered with aſtoniſhing force and vivacity of expreſſion in their eyes, and in the geſtures of their bodies. At this period of life, children are ſolely actuated by Nature and imitation. After they acquire words ſufficient for conveying the few ideas they poſſeſs, they begin to reaſon, or rather to employ the language of reaſoning; for, at this period of life, children, when they mean to give a reaſon why they ſhould have any indulgence or gratification, almoſt univerſally argue againſt themſelves, and employ a reaſon why their deſires ſhould not be granted. This ridiculous mode of reaſoning excites laughter, and affords pleaſure and amuſement to the parents. It likewiſe ſhows, that our firſt attempt toward reaſoning is principally, if not ſolely, the effect of imitation; for the reaſoning power,

power, at this period, is not fully unfolded, becaufe many human inftincts, or mental qualities, have not yet been called forth into action. But here I muft ftop. To do juftice to this interefting fubject would require volumes.

The love of offspring, which, though not univerfal, is perhaps the ftrongeft and moft active principle in human nature. It overcomes the fenfe of pain, and fometimes even the principle of felf-prefervation. A remarkable and a melancholy example of the ftrength of parental affection was lately exhibited, and, for the honour of our fpecies, deferves to be recorded. In the beginning of January 1786, the Halfewell Eaft Indiaman, Captain Richard Pierce, was unfortunately wrecked on the coaft of Dorfetfhire. Befide feveral other ladies, Captain Pierce had two of his own daughters on board. When the fhip was in the extremity of danger, fome of the company, by fwimming, and other feats of activity, got upon a rock. In this dreadful fituation, Captain Pierce afked Mr Rogers, his third mate, if any plan could be devifed for faving the ladies? Mr Rogers replied, 'It is impoffible! but you may fave yourfelf.' Upon which the Captain, addreffing himfelf to his daughters, and enfolding them in his arms, faid, 'Then, my dear children, we fhall 'not part; we fhall perifh together!' Mr Rogers quitted the fhip and reached the rock: An univerfal fhriek of defpair was heard, in which the voices of female diftrefs and horror were lamentably diftinguifhable. In a few moments all was hufhed; the fhip, with every perfon on board, had then gone to the bottom. Parents chearfully fubmit to the hardeft labour, and expofe themfelves to the greateft dangers in order to procure nourifhment to their young, or to protect them from injury.

A bitch, during the operation of diffection, licked her young, whofe prefence feemed to make her forget the moft excruciating tortures; and, when they were removed, ſhe uttered the moſt dolorous cries. Certain ſpecies of ſpiders incloſe their eggs in a ſilken bag ſpun and wove by themſelves. This bag they fix to their back, and carry it along with them wherever they go. They are extremely nimble in their motions. But, when the bag is forced from a ſpider of this kind, her natural agility forſakes her, and ſhe falls into a languid ſtate. When the bag is again preſented to her, ſhe inſtantly ſeizes it, and carries it off with rapidity. The young ſpiders no ſooner eſcape from the eggs than they dexterouſly arrange themſelves on the back of the mother, who continues for ſome time to carry them about with her, and to ſupply all their wants. Another ſpecies of ſpider attaches her bag of eggs to her belly. This ſpider is likewiſe very agile, and ſo ferocious and determined in the protection of her eggs, that ſhe has been known to ſuffer death rather than relinquiſh them. The deer ſpontaneouſly preſents herſelf to be chaced by the dogs, to prevent them from attacking her fawn. When the fox perceives that her young have been diſturbed in her abſence, ſhe carries them off, one after another, and conceals them in a new retreat. Waſps feed their young, when in the worm or caterpillar ſtate, in the ſame manner as pigeons and other birds that diſgorge. The pigeon, after ſwallowing grain, retains it for ſome time in her ſtomach, till it is ſoftened and macerated: She then diſgorges, and throws it into the mouths of her young. ‘ In the ſame manner,’ ſays Reaumur, ‘ I have obſerved a ‘ female waſp ſwallow a large portion of an inſect: In a ſhort time ‘ afterwards, ſhe traverſed the different cells of her neſt, diſgorged ‘ the contents of her ſtomach, and diſtributed food in this half di- ‘ geſted form to her young worms *.’

All animals, man perhaps not excepted, acquire a double portion of force and courage after they bring forth. A cow, at leaſt in a domeſtic

* Reaumur, tom. II. pag. 230. 12mo edit.

domeftic ftate, is a placid and phlegmatic animal: But, whenever fhe produces a calf, a wonderful change is exhibited: She inftantly becomes vigilant, active, and even ferocious, in the defence of her young. A lionefs deprived of her cubs prefents the moft dreadful picture of anxiety, rage, and rapacity. Defcending lower in the fcale of animation, the fame change is to be remarked. A domeftic hen is a timid, indocile, and obftinately ftupid creature. Though chaced, harraffed, and even put in danger of her life, fifty times in a day, fhe never learns to avoid a garden, or any particular place which fhe is accuftomed to frequent, or to which fhe is led by her appetite for food. But, the moment her chickens are hatched, inftead of her ufual timidity, fhe becomes as bold as a lion. When fhe thinks her young are in danger, fhe briftles up her feathers, affumes a fiercenefs in her eye, makes an alarming noife, and attacks, in the moft furious manner, and without diftinction, every animal that comes near her. By the fuddennefs of her onfets, fhe often alarms men, and actually intimidates and beats off dogs and other animals that could devour her in an inftant.

Though feveral of the infect tribes difcover a ftrong attachment to their young, yet all thofe which undergo transformations, and do not form focieties, muft be completely ignorant of the exiftence of their progeny; becaufe, in general, the parents die before the young are hatched. Nature, however, has endowed thofe fpecies with an inftinct which produces all the effects of parental affection: They uniformly depofit their eggs in fubftances which afford to the young, immediately after their efcape from the egg, a nourifhment adapted to their refpective conftitutions, and a comfortable and fafe protection from injury. Thus Nature, ever attentive to the continuation and happinefs of her productions, however feemingly infignificant in the fcale of being, often employs very different means to accomplifh the fame beneficent purpofes.

Nature has unqueſtionably attached pleaſure to all the neceſſary functions of animals. But this pleaſure cannot be conſidered as the original cauſe of any particular action; for the experiment muſt be made before the animal can diſcover whether the reſult is to be agreeable or diſagreeable. The truth is, that Nature has beſtowed on the minds of all animated creatures a number of laws or inſtincts perfectly accommodated to the ſpecies, and which irreſiſtibly compel them to perform certain actions. The effects of theſe laws we perceive: But the cauſes, or the modes by which they operate on animal minds, are inſcrutable. We may and muſt admire, but we can never penetrate the myſteries of Nature.

Bonnet, and ſome other naturaliſts, imagine they are exhibiting the cauſes of that ſtrong and mutual attachment between parents and their offspring, when they tell us, that, in man, and quadrupeds, and birds, the mother is fond of her young, becauſe their natural actions give riſe to agreeable ſenſations; that, from the ſtructure of the mammae, a gentle, but pleaſant ſenſation, is excited by the action of ſucking; that the mother is often incommoded by too great a quantity of milk, and that ſucking relieves her; that the young love their mother, becauſe ſhe feeds, protects, and communicates to them a cheriſhing warmth; that, among the feathered tribes, and particularly thoſe which ſit upon their young, by the gentle motions of the little ones, an agreeable ſenſation is excited in the belly of the mother, which is then frequently deprived of feathers. All theſe ſources of reciprocal pleaſure may be true: But ſtill they are only effects, and not original cauſes, of filial and parental affection; for that mutual attachment exiſts the moment after the young animals come into the world, and, of courſe, previous to all experience of titillation, of heat, of habit, or of any other circumſtances that may, perhaps, contribute to ſtrengthen or prolong the exertion of the primary

mary caufe, which muft remain forever concealed from human penetration.

In moft animals, except the human fpecies, parental and filial affection ceafe whenever the young are able to provide for themfelves. The pleafures derived from fucking, and from other circumftances formerly mentioned, might for fome time remain; but the young grow large, unwieldy, petulant, and enter into competitions for food, which not only contribute to alienate the affection of the parents, but even to excite refentment and averfion. Thefe, however, are only fecondary caufes. The purpofes of Nature are fulfilled. The ardour of affection, which was indifpenfably neceffary to the protection and rearing of the young, being now no longer ufeful, is fo totally extinguifhed, that neither the parents nor the offspring are capable of recognizing one another. This temporary and amiable inftinct is obliterated, and never revives till the fervours of love are again felt, and a new progeny appear.

Marriage or pairing, though by no means an univerfal inftitution of Nature, is not unfrequently exhibited in the animal creation. With regard to man, both male and female are inftinctively impelled to make a felection. The force of this natural impulfe is ftrongly felt by every young and uncorrupted individual. When not reftrained by neceffity, or other powerful motives, men and women would intermarry long before it would be prudent in civilized or artificial ftates of fociety. This univerfal, and almoft irrefiftible impulfe of felection, is to me the ftrongeft argument in favour of monogamy, or the union of pairs, among the human fpecies.

The fame impulfe, or law of Nature, takes place among many other animals, as the patridge tribes, the fwallow, the linnet, and, in general,

general, all the fmall birds. The affiduity, attention, mutual affection, laborious vigilance, and fteadfaft fidelity of pairing animals, are truly admirable, and, to ingenuous minds, afford the moft exemplary admonitions to virtue and conjugal attachment.

Befide this forcible impulfe of felection implanted by Nature in man, and in every other pairing animal, fome other facts deferve to be noticed. In all pairing animals, including, of courfe, the human race, the males and females produced are nearly equal. This is a plain indication that Nature deftined thefe animals to pair, or to marry. Injuftice, jealoufy, animofity, and every animal calamity, would enfue, if this order of Nature were encroached upon in creatures who are endowed with the inftinct of fexual felection.

It is not incurious to remark, that human inftitutions often contradict the laws of Nature. The dunghill cock and hen, in a natural ftate, pair. In a domeftic ftate, however, the cock is a jealous tyrant, and the hen a proftitute. But, even in this unnatural fociety, a felection is fometimes to be obferved. The fame phenomenon is exhibited among mankind, when placed in certain fituations. Like domeftic poultry, the Turks, and fome Afiatic and African nations, influenced by an accurfed government, and by an execrable religion, rebel againft the law of love, and of reciprocal attachment. In thefe countries, a rich man not only engroffes, but imprifons and tortures, as many beautiful women as his fortune enables him to fupport. Deftitute of all thofe endearments which arife from mental communication, from parental tendernefs and affection, from mutual confidence and folace, he is, while young, perpetually tormented with jealous apprehenfions. As he advances in life, his jealoufy and his terror augment. Though his females are fcrupuloufly guarded from every intrufion, by fervile and mutilated wretches, his fears increafe

increafe with his years and debility, till a premature and comfortlefs old age puts a period to his infignificant and liftlefs exiftence.

In general, it is to be remarked, that all thofe fpecies of animals, whofe offspring require, for fome time, the induftry and fupport of both parents, are endowed with the inftinct of felection, or of pairing. With regard to the feathered tribes, pairing is almoft univerfal. A diftinction, however, as to the duration and circumftances of their pairing is to be obferved. The young of all the fmall birds, as well as of moft of the larger kinds, continue for fome weeks in a weak and helplefs condition. The mother is not, like quadrupeds, provided with organs fitted to fecrete milk; of courfe, fhe is unable to nourifh them out of her own body. She is therefore obliged to go abroad in queft of food for them. But the progeny are fo numerous, that all her induftry, if not affifted by the father, would be ineffectual for their fupport and protection. In all birds whofe young are in this condition, the males and females not only pair, but each of them is endowed with the ftrongeft parental affection. Both are equally anxious and induftrious in procuring food for their mutual offspring. This parental care and attachment uniformly continues till the young are fledged, and have acquired fufficient ftrength to provide for themfelves. Eagles, and fome other birds of prey, continue faithfully in pairs for years, and perhaps during life. Thefe facts afford a ftrong argument in favour of marriage among mankind. No animal remains fo long in the infant and helplefs ftate as the children of men; and no mother could, with her own induftry, poffibly fuckle and procure nourifhment for a numerous family. Here, as in the feathered tribes, the affiftance of the father becomes indifpenfable. On this fubject, a curious inftinct merits attention. The male of moft birds not only felects a female, but, with great affiduity, brings food to her when fitting on her eggs, and often relieves her, by fitting on them himfelf.

There are other ſpecies of pairing birds, whoſe young, as ſoon as they are hatched, are capable of eating their food when preſented to them, and of courſe, require leſs labour from the parents. In theſe ſpecies, accordingly, the male pays no attention to the progeny, becauſe it is unneceſſary; but the mother carefully leads them about to places where proper food is to be had, protects them from injuries, and communicates heat to them by covering them with her wings.

Quadrupeds, eſpecially thoſe which feed upon graſs, do not pair; becauſe, while the female gives ſuck to her young, ſhe herſelf is feeding. Beſide, the young of this tribe, very ſoon after birth, can eat graſs and other vegetables. The Count de Buffon remarks, that the roe-deer, though they feed upon graſs, are to be excepted from this rule; for they pair, and have annually but one litter. Lions, tigers, wolves, and other rapacious quadrupeds, do not pair. The whole labour of procuring food is devolved upon the female, which often ſhortens her own life, as well as that of her offspring. In relation to man, this is a fortunate circumſtance; for, if beaſts of prey paired, a dangerous multiplication of thoſe deſtructive ſpecies would be the conſequence. But pairing is eſſentially neceſſary to birds of prey; becauſe, during the proceſs of incubation, the female would not have time ſufficient for procuring food; which, in theſe animals, requires both patience and addreſs. Some quadrupeds, particularly thoſe which lay up proviſions for the winter, as the beaver, pair. As ſoon as the young beavers are produced, the males abandon the ſtock of proviſions to the females, and go in queſt of food for themſelves. But they by no means relinquiſh their mates; but frequently return and viſit them while they are ſuckling their young.

If man, and ſome of the pairing animals be excepted, the ſeaſons of love are limited to particular times of the year. Theſe ſeaſons, though

though various, are admirably adapted to the nature and oeconomy of the different ſpecies. In all animals of this kind, the ſeaſons of love, and the times of female geſtation, are ſo contrived by Nature, that the offspring, when brought forth, are amply ſupplied with the particular ſpecies of food upon which they principally live. Though the times of geſtation vary conſiderably among ſuch quadrupeds as feed upon graſs, the reſpective females uniformly bring forth early in ſummer, when the graſs is tender and luxuriant. The mare comes in ſeaſon in ſummer, carries eleven months, and is delivered in the beginning of May. Sheep and goats come in ſeaſon in the end of October or beginning of November. They carry five months, and produce when the graſs begins to ſpring. It is worthy of obſervation, that, though the times of geſtation in the ſame ſpecies, and in all latitudes, never alter, yet the ſeaſons of love, and times of delivery, vary with the climate. In Italy, ſheep come in ſeaſon in the months of June or July. The females, as uſual, carry five months, and bring forth in November or December, the very period when graſs, in that climate, is in its beſt ſtate for paſture; for, in April, it is burnt up, and ſheep have nothing to browſe upon but ſhrubs. The rutting ſeaſon of the ſtag is in the end of September and beginning of October, and the female brings forth in May or the beginning of June. Theſe animals inhabit the higheſt mountains of Scotland, where the graſs, of courſe, does not begin to ſpring ſo early as in the lower parts of that country. Beavers come in ſeaſon about the end of autumn, and bring forth in January, when their ſtore-houſes are full of proviſions. The young of pairing birds are produced in the ſpring, when the weather begins to be comfortably warm, and their natural food abounds. In a word, the bringing forth, or hatching, of all animals, not excluding the inſect tribes, uniformly takes place at thoſe ſeaſons of the year when the nature of the weather, and the food peculiar to the ſpecies, are beſt adapted to the conſtitution of their offspring. Caterpillars of every kind are

2 † Nn never

never hatched till the various plants on which they feed, though they grow in different months, have put forth their leaves.

We ſhall conclude this ſubject, by giving a Table of the Relative Fecundity, &c. of Animals, which, in a ſhort compaſs, ſolves a number of queſtions with regard to the natural hiſtory of quadrupeds. It is taken from the eighth volume of the Tranſlation of Buffon, to whoſe authority moſt readers will be inclined to give great weight.

TABLE

TABLE of the RELATIVE FECUNDITY of ANIMALS.

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of geſtation.	Number of young produced at a litter.	Age at which Males ceaſe to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Elephant	30	30	2 years	1 in three or four years	lives 200	
Rhinoceros	15 or 20	15 or 20		1	lives 70 or 80	
Hippopotamus				1		
Walrus			9 months	1		
Camel	4	4	1 year nearly	1	lives 40 or 50	
Dromedary	4	4	idem	1	lives 40 or 50	
Horſe	$2\frac{1}{2}$	2	11 months	1, ſometimes 2.	at 25 or 30	at 18 or 20
Zebra	2	2	11 ditto	1, rarely 2	at 25 or 30	at 18 or 20
Aſs	2	2	11 ditto & more	1, rarely 2	at 25 or 30	at 25 or 30
Buffalo	3	3	9 months	1	lives 15 or 18	
Ox	2	$1\frac{1}{2}$	9 ditto	1, rarely 2	at 9	at 9
Stag	$1\frac{1}{2}$	$1\frac{1}{2}$	8 ditto & more	1, rarely 2	lives 30 or 35	
Rain-deer	2	2	8 months	1	lives 16	
Lama	3	3		1, rarely 2	at 12	at 12
Man	14	12	9 months	1, ſometimes 2		
Large Apes	3	3		1, ſometimes 2		
Mouflon	$1\frac{1}{2}$	1	5 ditto	1, ſometimes 2 twice a year in hot climates	at 8	at 10 or 12
Saiga	1	1	5 ditto	1, ſometimes 2	lives 15 or 20	
Roebuck	$1\frac{1}{2}$	2	5 ditto	1, 2, ſometimes 3	lives 12 or 15	
Chamois Goat	1	1	5 ditto	1, 2, rarely 3	lives 20	
Goat	1	7 months	5 ditto	1, 2, rarely 3, and never above 4	at 7	at 7
Sheep	1	1	5 ditto	1, ſometimes 2, twice a year in warm climates	at 8	at 10 or 12

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of geftation.	Number of young produced at a litter.	Age at which Males ceafe to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Seal			feveral months	2 or 3		
Bear	2	2	ditto	1, 2, 3, 4, and never above 5	lives 20 or 25	
Badger				3 or 4		
Lion	2	2		3 or 4 once a year	lives 20 or 25	
Leopard and Tiger	2	2		4 or 5 once a year		
Wolf	2	2	73 days or more	5, 6, to 9, once a year	at 15 or 20	at 15 or 20
Dog in a natural ftate	9 or 10 months	9 or 10 months	63 days	3, 4, 5, 6	at 15	at 15
Ifatis			63 days	6 and 7		
Fox	1	1	In feafon in winter, and produces in April	3, 4, to 6	at 10 or 11	at 10 or 11
Jackal				2, 3, or 4		
Cat in a natural ftate	before 1	before 1	56 days	4, 5, or 6	at 9	at 9
Martin	1	1	56 days, it is faid	3, 4, and 6	at 8 or 10	at 8 or 10
Pine Weafel	1	1	idem	3, 4, and 6	at 8 or 10	at 8 or 10
Polecat	1	1	idem	3, 4, and 5	gener. during life	prod. during life
Weafel	1ft year	1ft year		3, 4, and 5	idem	idem
Ermine	idem	idem		idem	idem	idem
Squirrel	1	1	copulates in March, and produces in May	3 or 4	idem	idem
Flying Squirrel				3 or 4		
Hedgehog	1	1	40 days	3, 4, and 5		
Dormice	1ft year	1ft year		3, 4, and 5	lives 6	
Mufk Rats				4, 5, or 6		

Names.	Age at which Males can engender, and Females produce. MALE. Years.	FEMALE. Years.	Times of geſtation.	Number of young produced at a litter.	Age at which Males ceaſe to engender, and Females to produce. MALE. Years.	FEMALE. Years.
Opoſſums	. .	. .	. .	4, 5, 6, and 7		
Hogs	1 year or 9 mos.	1 year or 9 mos.	4 months	10, 12, 15, to 20, twice a year	at 15	at 15
Armadillos	. .	. .	. .	4 ſeveral times a year		
Hare	1ſt year	1ſt year	30 or 31 days	2, 3, 4, ſeveral times a year	lives 7 or 8	
Rabbit	5 or 6 months	5 or 6 months	idem	4, 5, to 8, ſeveral times a year	idem	
Ferret	1ſt year	1ſt year	40 days	5, 6, to 9, twice a year	during life	
Rats	idem	idem	5 or 6 weeks	5 or 6 ſeveral times a year	idem	
Field Mice	idem	idem	1 month, or 5 weeks	9 or 10 ſeveral times a year		
Mouſe	idem	idem	idem	5 or 6 ſeveral times a year	idem	
Brown Rat	idem	idem	. .	12 to 19 thrice a year	idem	
Guinea Pig	5 or 6 weeks	5 or 6 weeks	3 weeks	eight times a year; 1ſt litter, 4 or 5; 2d, 5 or 6; and the others, 7, 8, to 11	lives 6 or 7, and produces during life	

CHAPTER XII.

Of the Transformation of Animals.

THE transformation of caterpillars, and of different kinds of worms, into winged infects, has long excited the attention, as well as the admiration of mankind. But the truth is, that every animal, without exception, undergoes changes in their ftructure, mode of exiftence, and external appearances. Mankind, from their embryo ftate, to their final diffolution, affume many different forms. Some weeks after conception, the rudiments of a human being are to be perceived. As pregnancy advances, the approaches to the perfect figure become gradually more diftinguifhable, till the period of birth. While in the foetus ftate, the head is difproportionally large, when compared with the other parts of the body; nourifhment is conveyed to it by very different channels; and refpiration is not neceffary, becaufe the circulation of the blood is not carried on in the fame manner as after birth. Even after birth, the form, fymmetry, and organs of the animal are by no means complete. The head continues for fome time to be difproportionally large; the hands and feet are not properly fhaped; the legs are crooked; the hair on the head is fhort and fcanty; no teeth as yet appear; and there is not a veftige of a beard. In a few months, however, the fymmetry of all the

the parts is evidently improved, and the teeth begin to ſhoot. The growth of the whole body, as well as the ſtrength and beauty of its form, gradually advance to perfection till the ſixth or ſeventh year, when another change takes place. At this period, the firſt ſet of teeth are ſhed, and are replaced by new ones. From boyhood to puberty, the ſize of the body, and of its different members, increaſe. When the age of puberty arrives, ſeveral important changes are produced in the ſyſtem of both males and females. The beard now makes its appearance; the dimenſions of the body, in moſt individuals, are ſuddenly augmented; and both ſexes become capable of multiplying the ſpecies. From this period, to the age of twenty-five or thirty, the muſcles ſwell, their interſtices are filled with fat, the parts bear a proper proportion to each other, and man may now be conſidered as a perfect animal. In this ſtate of bodily perfection and vigour, he generally remains till he reaches his fiftieth year. Then a new but a gradual change begins to appear. From the fiftieth year to the age of ſeventy or eighty, the powers of the body decline in their ſtrength and activity. The muſcles loſe their ſpring and their force. The vigour of manhood is no longer felt; and the withered decrepitude of old age is ſucceeded by death, its unavoidable conſequence.

The mind of man undergoes changes as well as his body. The taſte, the appetites, and the diſpoſitions, are in perpetual fluctuation. How different is the taſte of a child from that of a man? Fond of gewgaws and of trifling amuſements, children frolic away their time without much thought or reflection. When advancing toward puberty, their diſpoſitions and deſires ſuffer a gradual mutation. New inſtincts are unfolded, and a ſenſe of propriety begins to be perceived. They deſpiſe their former occupations and amuſements; and different ſpecies of objects ſollicit and obtain their attention. Their powers of reflection are now conſiderably augmented; and both ſexes acquire a modeſty and a ſhyneſs with regard to each other. This aukward, but natural baſhfulneſs, by the intercourſe of ſociety, as well as by the impulſes of Nature, vaniſhes ſoon after puberty, when the ſtate of manhood and of gallantry commences. From this period, to the age of twenty-five or thirty, men's minds aſſume a bold, enterpriſing, and active tone. They engage in the buſineſs of life, look forward to futurity, and have a deſire of marrying, and of eſtabliſhing families. All the ſocial appetites are in vigour; ſolid and manly friendſhips are formed; and man goes on for ſome time to enjoy every kind of happineſs which his nature is capable of affording. I wiſh the next change had no exiſtence. At fifty or ſixty, the mental powers, in general, like thoſe of the body, begin to decline, till feeble and tremulous old age arrives, and death cloſes the mutable ſcene of human life.

With regard to *quadrupeds*, both before and after birth, they undergo ſimilar, and many of them greater, changes of form than thoſe of the human ſpecies. Their mental powers, likewiſe, their diſpoſitions and manners, as well as the objects of their attention, vary according to the different ſtages of their exiſtence. Many of them come into the world blind, and continue for ſome time before they receive the ſenſe of ſeeing. How many changes are exhibited in the dog from birth till he becomes a perfect animal, till all his members are completely formed, and all his inſtincts are unfolded and improved by experience and education? The deer-kind acquire not their magnificent and beautiful horns before the age of puberty; and even theſe are annually caſt off and renewed. Similar changes take place in quadrupeds of every denomination; with examples of which every man's experience and recollection will readily ſupply him; and, therefore, it is unneceſſary to be more particular.

Neither

Neither are *Birds*, in their progreſs from birth to maturity, exempted from changes. Like quadrupeds, many birds are blind for ſome time after they are hatched. In this condition, how different are their form and appearances from thoſe of the perfect animals! At firſt, they are covered with a kind of down inſtead of feathers. Even after the feathers ſhoot, they are often of a colour different from that which they acquire when full grown. The beautifully variegated colours of the peacock's tail appear not till he arrives at his third year *. Birds that have creſts, or wattles, live a conſiderable time before they acquire theſe ornaments, or marks of diſtinction. All birds annually molt, or caſt their feathers, in the ſame manner as quadrupeds ſhed their hair, the new puſhing out the old.

Frogs, and many other *amphibious* animals, undergo great changes in their form and ſtructure. When it firſt eſcapes from the egg, a frog appears in the form of a tadpole, an animal with a large roundiſh head, and a compreſſed or flat tail, but totally deſtitute of feet and legs. In this ſtate it remains a conſiderable time, when the two fore-feet begin to ſhoot, and have an exact reſemblance to the buds of trees. As their growth advances, the toes and legs are diſtinguiſhable. The ſame proceſs goes on with the hind-legs, only they are ſomewhat later in making their appearance. During the growth of the legs, the blood being drawn into different channels, the tail ſuffers a gradual mortification, till at laſt it totally vaniſhes, and the tadpole is metamorphoſed into a quadruped. Tadpoles never come out of the water; but, after their transformation into frogs, they become amphibious, and occaſionally frequent both land and water.

* Linnaei Amoen. Acad. vol. 4. p. 368.

The *cruſtaceous* tribes, as lobſters, crabs, &c. beſide the different appearances they aſſume while growing to perfection, caſt their ſhells every year. When this change is about to happen, they retire into the crevices of rocks, or ſhelter themſelves below detached ſtones, with a view to conceal and defend their bodies from the rapacious attacks of other fiſhes. After the ſhells are caſt, the animals are exceedingly weak and defenceleſs. Inſtead of their natural defence of hard ſhells, and ſtrong claws, they are covered only with a thin membrane or ſkin. In this ſtate they become an eaſy prey to almoſt every fiſh that ſwims. The ſkin, however, gradually thickens and grows harder, till it acquires the uſual degree of firmneſs. By this time the animals have reſumed their former ſtrength and activity; they come out from their retirements, and go about in queſt of food.

Serpents, and many other *reptiles*, caſt their ſkins annually. The beauty and luſtre of their colours are then highly augmented. Before caſting, the old ſkins have a tarniſhed and withered appearance. The old ſkins, like the firſt ſet of teeth in children, are forced off by the growth of the new.

We come now to give ſome account of the transformations of *inſects*, which are both various and wonderful. All winged inſects, without exception, and many of thoſe which are deſtitute of wings, muſt paſs through ſeveral changes before the animals arrive at the perfection of their natures. The appearance, the ſtructure, and the organs of a caterpillar, of a chryſalis, and of a fly, are ſo different, that, to a perſon unacquainted with their transformations, an identical animal would be conſidered as three diſtinct ſpecies. Without the aid of experience, who could believe that a butterfly, adorned with four beautiful wings, furniſhed with a long ſpiral proboſcis or tongue, inſtead of a mouth, and with ſix legs, ſhould have proceeded from a difgufting, hairy caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long, white, fmooth, foft worm, hid under the earth, fhould be tranf-formed into a black, cruftaceous beetle, having wings covered with horny elytra, or cafes?

Upon this branch of the fubject, we fhall, *firft*, give an example or two of the moft common transformations of Infects; and, *fecondly*, defcribe fome of the more uncommon kinds.

Befide their final metamorphofis into flies, caterpillars undergo feveral intermediate changes. All caterpillars caft or change their fkins oftener or more feldom, according to the fpecies. Malpighius informs us, that the filk-worm, previous to its chryfalis ftate, cafts its fkin four times. The firft fkin is caft on the 10th, 11th, or 12th day, according to the nature of the feafon; the fecond in five or fix days after; the third in five or fix days more; and the fourth and laft in fix or feven days after the third. This changing of fkin is not only common to all caterpillars, but to every infect whatever. Not one of them arrives at perfection without cafting its fkin at leaft once or twice. The fkin, after it is caft, preferves fo entirely the figure of the caterpillar in its head, teeth, legs, colour, hair, &c. that it is often miftaken for the animal itfelf. A day or two before this change happens, caterpillars take no food: They lofe their former activity, attach themfelves to a particular place, and bend their bodies in various directions, till at laft they efcape from the old fkin, and leave it behind them. The inteftinal canal of caterpillars is compofed of two principal tubes, the one inferted into the other. The external tube is compact and flefhy; but the internal one is thin and tranfparent. Some days before caterpillars change into the chryfalis ftate, they void, along with their excrement, the inner tube which lined their ftomach and inteftines. When about to pafs into the chryfalis ftate, which is a ftate of imbecillity, caterpillars felect the moft proper places and modes of concealing themfelves from their enemies. Some, as the filk-worm, and many others, fpin filken webs or cods round their bodies, which completely difguife the animal form. Others leave the plants upon which they formerly fed, and hide themfelves in little cells which they make in the earth. The rat-tailed worm abandons the water upon the approach of its metamorphofis, retires under the earth, where it is changed into a chryfalis, and, after a certain time, burfts from its feemingly inanimate condition, and appears in the form of a winged infect. Thus the fame animals pafs the firft and longeft period of their exiftence in the water, another under the earth, and the third and laft in the air. Some caterpillars, when about to change into a chryfalis ftate, cover their bodies with a mixture of earth and of filk, and conceal themfelves in the loofe foil. Others incruft themfelves with a filky or glutinous matter, which they pufh out from their mouths, without fpinning it into threads. Others retire into the holes of walls or of decayed trees. Others fufpend themfelves to the twigs of trees, or to other elevated bodies, with their heads undermoft. Some attach themfelves to walls, with their heads higher than their bodies, but in various inclinations; and others choofe a horizontal pofition. Some fix themfelves by a gluten, and fpin a rope round their middle to prevent them from falling. Thofe which feed upon trees attach themfelves to the branches, inftead of the leaves, which are lefs durable, and fubject to a greater variety of accidents. The colours of the caterpillars give no idea of thofe of the future flies.

In general, the figure of chryfalids approaches to that of a cone, efpecially in their pofterior part. When under this form, the infect feems to have neither legs nor wings. It is incapable either of walking or of crawling. It takes no nourifhment, becaufe it has no organs fuited to that purpofe; yet, in fome fpecies, life is continued for feveral months before their laft metamorphofis takes place. In a word, it feems to be a lifelefs mafs. But, upon a more attentive obfervation, it poffeffes the power of bending upwards and downwards the pofterior part of its body. The fkin, or exterior covering, of thofe which do not fpin cods, feems to be of a cartilaginous nature. It is commonly fmooth and fhining. In fome fpecies, however, the fkin of the chryfalis is more or lefs covered with hair, and other rugofities. Though chryfalids differ both in figure and colour, their appearances are by no means fo various as thofe of the caterpillars from which they are produced. The colour of fome chryfalids is that of pure gold, from which circumftance the whole have received their denomination. For the fame reafon they are called *aureliae* in Latin. Some are brown, others green; and, indeed, they are to be found of almoft every colour and fhade.

The life of winged infects confifts of three principal periods, which prefent very different fcenes to the ftudent of Nature. In the firft period, the infect appears under the form of a *worm* or *caterpillar*. Its body is long, cylindrical, and confifts of a fucceffion of rings, which are generally membranous, and encafed within each other. By the aid of its rings, or of crotchets, or of feveral pairs of legs, it crawls about in queft of food; and its movements are, in fome fpecies, remarkably quick. Its head is armed with teeth, or pincers, by which it eats the leaves of plants or other kinds of food. In this ftate, it is abfolutely deprived of fex, and, confequently, of the power of multiplication. Its blood moves from the tail toward the head. It refpires either by ftigmata or fmall apertures placed on each fide of its body, or by one or feveral tubes fituated on its pofterior part, which have the refemblance of fo many tails. In the fecond period, the infect appears under the form of a nymph, or that of a chryfalis. When an infect, after throwing off the fkin of the caterpillar, exhibits all its external parts, only covered with foft and

transparent

tranſparent membranes, it is called a *nymph*. But, when to theſe membranes is added a common and cruſtaceous covering, it receives the name of a *chryſalis*. While in the ſtate of a nymph, or that of a chryſalis, inſects, in general, are totally inactive, and ſeem not to poſſeſs any powers of life. Sunk into a kind of deep ſleep, they are little affected with external objects. They can make no uſe of their eyes, their mouth, or any of their members; for they are all impriſoned by coverings more or leſs ſtrong. No cares occupy their attention. Deprived of the faculty of motion, they remain fixed in thoſe ſituations which they have choſen for their temporary abode, or where chance has placed them, till their final metamorphoſis into flies. Some of them, however, are capable of changing place; but their movements are ſlow and painful. Their blood circulates, but in a contrary direction from what takes place in the caterpillar ſtate; for it proceeds from the head toward the tail. Reſpiration continues to go on, but the organs are differently ſituated. In the caterpillar, the principal organs of reſpiration were placed at the poſterior part of the body; but now theſe ſame organs are to be found at the anterior part of the animal. In the third period, the inſect has acquired that perfect organization which correſponds to the rank it is to hold in the ſcale of animation. The bonds of the nymph, or of the chryſalis, are now burſt aſunder, and the inſect commences a new mode of exiſtence. All its members, formerly ſoft, inactive, and folded up in an envelope, are expanded, ſtrengthened, and expoſed to obſervation. Under the form of a worm or caterpillar, it crawled; under thoſe of a nymph, or chryſalis, its power of motion was almoſt annihilated; under the laſt form, it is furniſhed with ſix ſpringy legs, and two or four wings with which it is enabled to fly through the air. Inſtead of teeth or pincers, with which it divided a groſs aliment, it has now a trunk by which it extracts the refined juices of the moſt delicate flowers. Inſtead of a few ſmooth eyes which it poſſeſſed in the worm or caterpillar ſtate, the

the new infect is furnifhed with both fmooth and convex eyes, to the number of feveral thoufands.

The internal parts of the infect have likewife undergone as many changes as the external. The texture, the proportions, and the number of the vifcera, are greatly altered. Some have acquired an additional degree of confiftence; others, on the contrary, are rendered finer and more delicate. Some receive a new form, and others are entirely annihilated. Laftly, fome organs in the perfect infect, which feemed formerly to have no exiftence, are unfolded, and become vifible. The moft important of this laft kind are the organs of generation. The caterpillar, the nymph, and the chryfalis, were of no fex. But, after transformation, both fexes are diftinguifhable, and the animals are capable of multiplying their fpecies.

We fhall now give fome examples of transformations which deviate from the common mode.

Some infects hold a middle rank between thofe which preferve their original figure during life, and thofe that fuffer transformations. Their exiftence is divided into two periods only. They walk in the firft, and fly in the fecond. Thus their only metamorphofis confifts of the addition of wings, the growth and expanfion of which are performed without any confiderable alteration in the figure of their bodies.

There is not a law eftablifhed among organized bodies which feems to be fo univerfal, as that all of them grow, or augment in fize, after birth, till they arrive at maturity. If a hen were to bring forth an egg as large as her own body, and if this egg, when hatched, were to produce a bird of equal dimenfions with either of the parents, it would be confidered as a miracle. But the *fpider-fly*, fo denominated

denominated from its figure, affords an example of a ſimilar prodigy. This fly actually lays an egg, from which a new fly is hatched that is as large and as perfect as its mother. This egg is roundiſh, is at firſt white, and afterwards aſſumes a ſhining black colour. Upon a more accurate examination, however, this production was found to be an egg only in appearance. When the envelope is removed, inſtead of a gelatinous ſubſtance, the new inſect, furniſhed with all its members, is diſcovered. But this diſcovery does not render the fact the leſs wonderful. All winged inſects undergo their different transformations after being expelled from the bodies of their mothers, and receive great augmentations of ſize before their metamorphoſis into the nymph or chryſalis ſtate, after which their growth ſtops. But the ſpider-fly affords an inſtance of an inſect transformed in the belly of its mother, and which grows no more after it eſcapes from its envelope. This fact is fully authenticated by Reaumur *, Bonnet †, and other naturaliſts.

The worm from which the tipula or crane-fly is produced is perfectly ſmooth. Immediately before its firſt transformation it retires under ground. After this metamorphoſis, the ſurface of the nymph is furniſhed with a number of prickles. By means of theſe prickles, the nymph, when about to be transformed into a fly, raiſes itſelf in its hole till the cheſt of the inſect is above ground. The fly then burſts its priſon, mounts into the air, and leaves its former covering behind in the earth.

Many ſpecies of flies depoſit their eggs in the leaves and different parts of plants. Soon after the egg is inſerted into the leaf, a ſmall tubercle begins to appear, which gradually increaſes in magnitude till

* Reaumur, vol. 12. p. 412. edit. 12mo.

† Oeuvres de Bonnet, vol. 4. p. 28. edit. 8vo.

till the animal is hatched, and has paffed through its different tranf-formations. Thefe tubercles are known by the name of *galls*, and are very different in their form, texture, colour, and fize. Galls of every kind, however, derive their origin from the ftings of infects, which generally belong to the clafs of flies. The female fly, by means of her fting, makes incifions in the leaves or branches of a tree, and in each incifion fhe lays an egg. This egg is at firft extremely minute; but it foon acquires a confiderable bulk, and the gall has arrived at its full fize before the worm is hatched. This gall feems to be analogous to the membranes which inveft a foetus, and expand in all directions in proportion to its growth. That the eggs of oviparous animals grow while in the ovarium is univerfally known; but it is fingular that the eggs of gall-flies fhould grow after being feparated from the body of the mother. Thefe eggs muft undoubtedly be furnifhed with external veffels, or a kind of roots, by which they extract juices from the internal cavity of the gall. Malpighius afcribes the origin of galls to a corrofive liquor introduced by the fly into the wound. But Reaumur, to account for the growth of a gall, thinks it unneceffary to have recourfe to any fuppofed poifonous fluids, and attributes it to the fuperabundant nutricious juices derived to that particular part by the continual action of the abforbent veffels of the egg, joined to its heat, which may be compared to a little fire placed in the center of the tumour.

Whether thefe caufes are fufficient to explain the growth of galls, we fhall fubmit to the judgment of the reader. But, that the eggs depofited by the flies augment in fize; that worms proceed from them; that thefe worms are nourifhed, and live a certain time imprifoned in the galls; that they are there transformed into nymphs or chryfalids; and, laftly, that they are metamorphofed into winged infects, which, by gnawing an aperture through the gall, take their flight in the air; are known and inconteftible facts, of the truth of which every man may eafily fatisfy himfelf. Examine the common oak-galls, or thofe of any other tree; if any of them happen to have no aperture, cut them gently open, and you are certain to find an egg, a worm, a chryfalis, or a fly: But in fuch as are perforated by a cylindrical hole, not a veftige of an animal is difcoverable. The galls which make an ingredient in the compofition of ink are thick, and their texture is very ftrong and compact: That the fmall animals they contain fhould be able to pierce through fuch a rigid fubftance is truly wonderful.

In the general order of Nature among oviparous animals, each egg includes one embryo only. A fingular fpecies of eggs, however, difcovered by the celebrated Mr Folks, late Prefident of the Royal Society of London, muft be excepted. He found great numbers of them in the mud of fmall rivulets. In fize they equalled the head of an ordinary pin. They were of a brown colour, and their furface was cruftaceous, through which, by employing the microfcope, feveral living worms were diftinctly perceptible. By dexteroufly breaking the fhell, he diflodged them; and he found with furprife, that eight or nine worms were contained in, and proceeded from, the fame egg. They were all well formed, and moved about with great agility. Each of them was inclofed in an individual membranous covering, which was extremely thin and tranfparent. It were to be wifhed that the transformations of thefe extraordinary animals had been traced.

Some caterpillars, when about to transform, make a belt pafs round their bodies. This belt is compofed of an affemblage of filken threads fpun by themfelves, the ends of which they pafte to the twigs of bufhes, or other places where they choofe to attach their bodies. They likewife fix their hind legs in a tuft of filk. After transformation, the chryfalids remain fixed in the fame manner as before

before their metamorphofis. The belt is loofe, and allows the chryfalis to perform its flow and feeble movements.

The whole moth-kind, as well as the filk-worm, immediately before their transformation into the chryfalis ftate, cover their bodies with a cod or clue of filk, though the nature of the filk, and their mode of fpinning, are very different. The cods of the filk-worm are compofed of pure filk. Their figure is generally oval, which neceffarily refults from that of the animal's body upon which they are moulded. When fpinning, they twift their bodies into the form of an S. The cod is produced by numberlefs circumvolutions and zigzags of the fame thread. The filk is fpun by an inftrument fituated near the mouth of the infect. The filky matter, before it is manufactured by the fpinning inftrument, appears under the form of a gum almoft liquid, which is contained in two large refervoirs contorted like the inteftines of larger animals, and which terminate at the fpinning inftrument by two parallel and flender conduits. Each conduit furnifhes matter for one thread. The fpinning inftrument, as is evident when viewed by the microfcope, unites the two threads into one. Thus a thread of filk, which has the appearance of being fingle, is in reality double, and fpun with great dexterity. Some writers, who delight in the marvellous, afcribe forefight to the filk-worm in fpinning its cod. The filk-worm, it muft be acknowledged, acts as if it forefaw the approaching event. But the truth is, that, when the animal has acquired its full growth, its refervoirs of filk are completely filled. It then feems to be ftrongly ftimulated to evacuate this glutinous matter. Its different movements and attitudes, while difcharging the filk, produce thofe oval bundles which clothe and ornament vaft numbers of the human fpecies.

 Another

Another ſpecies of caterpillar conſtructs its cod in the form of a boat with the keel uppermoſt; but it conſiſts not entirely of pure ſilk. The animal, with its teeth, detaches ſmall triangular pieces of bark from a buſh or a tree. Theſe pieces of bark it paſtes upon its body by means of a glutinous or ſilky ſubſtance, and they conſtitute a principal part of its cod.

Another ſpecies works alſo in wood, though not with equal art as the former. Its cod is compoſed entirely of ſmall irregular fragments of dried wood. Theſe fragments the animal has the addreſs to unite together, and to form of them a kind of box which covers and defends its whole body. It accompliſhes this purpoſe by moiſtening, for ſome moments, the pieces of wood in its mouth, and then attaches them to each other by a glutinous ſubſtance. Of this mixture the caterpillar forms a cod, the ſolidity of which is nearly equal to that of wood.

The moſt ſolitary of all inſects are thoſe who live in the internal parts of fruits. Many of them undergo their metamorphoſis in the fruit itſelf, which affords them both nouriſhment and a ſafe retreat. They dig cavities in the fruit, which ſome of them either line with ſilk, or ſpin cods. Others leave the fruit, and retire to be transformed in the earth.

The metamorphoſis of inſects has been regarded as a ſudden operation, becauſe they often burſt their ſhell or ſilky covering quickly, and immediately appear furniſhed with wings. But, by more attentive obſervation, it has been diſcovered that the transformation of caterpillars is a gradual proceſs from the moment the animals are hatched till they arrive at a ſtate of perfection. Why, it may be aſked, do caterpillars ſo frequently caſt their ſkins? The new ſkin, and other organs, were lodged under the old ones, as in ſo many

tubes

tubes or cafes, and the animal retires from thefe cafes, becaufe they have become too ftrait. The reality of thefe encafements has been demonftrated by a fimple experiment. When about to molt or caft its fkin, if the foremoft legs of a caterpillar are cut off, the animal comes out of the old fkin deprived of thefe legs. From this fact, Reaumur conjectured, that the chryfalis might be thus encafed, and concealed under the laft fkin of the caterpillar. He difcovered that the chryfalis, or rather the butterfly itfelf, was inclofed in the body of the caterpillar. The probofcis, the antennae, the limbs, and the wings, of the fly are fo nicely folded up, that they occupy a fmall fpace only under the two firft rings of the caterpillar. In the firft fix limbs of the caterpillar are encafed the fix limbs of the butterfly. Even the eggs of the butterfly have been difcovered in the caterpillar long before its transformation.

From thefe facts it appears, that the transformation of infects is only the throwing off external and temporary coverings, and not an alteration of the original form. Caterpillars may be confidered as analogous to the foetufes of men and of quadrupeds. They live and receive nourifhment in envelopes till they acquire fuch a degree of perfection as enables them to fupport the fituation to which they are ultimately deftined by Nature.

One would not readily believe that the *excrements* of a butterfly fhould be capable of exciting conftemation in the minds of the people. But this event has frequently happened in different places and nations. Among many other prodigies which have terrified nations, *fhowers of blood* have been enumerated by hiftorians. Thefe fhowers of blood were fuppofed to portend great and calamitous events, as wars, the deftruction of cities, and the overthrow of empires. About the beginning of July, in the year 1608, one of thefe pretended fhowers of blood fell in the fuburbs of Aix, and for feveral miles round.

round. This ſuppoſed ſhower of blood, M. de Reaumur remarks, would probably have been tranſmitted to us as a great and a real prodigy, if Aix had not then been poſſeſſed of a philoſopher, who, amidſt other ſpecies of knowledge, did not neglect the operations and oeconomy of inſects. This philoſopher was M. de Peireſc, whoſe life is written by Gaſſendi. This life contains a number of curious facts and obſervations. Among others, M. de Peireſc diſcovered the cauſe of the pretended ſhower of blood at Aix, which had created ſo general an alarm. About the beginning of July, the walls of a church-yard adjacent to the city, and particularly the walls of the ſmall villages in the neighbourhood, were obſerved to be ſpotted with large drops of a blood-coloured liquid. The people, as well as ſome theologians, conſidered thoſe drops as the operation of ſorcerers, or of the Devil himſelf. M. de Peireſc, about that time, had picked up a large and beautiful chryſalis, which he laid in a box. Immediately after its transformation into the butterfly ſtate, M. de Peireſc remarked, that it had left a drop of blood-coloured liquor on the bottom of the box, and that this drop, or ſtain, was as large as a French ſou. The red ſtains on the walls, on ſtones near the highways, and in the fields, were found to be perfectly ſimilar to that on the bottom of M. de Peireſc's box. He now no longer heſitated to pronounce, that all thoſe blood-coloured ſtains, wherever they appeared, proceeded from the ſame cauſe. The prodigious number of butterflies which he, at the ſame time, ſaw flying in the air, confirmed his original idea. He likewiſe obſerved, that the drops of the miraculous rain were never found in the middle of the city; that they appeared only in places bordering upon the country; and that they never fell upon the tops of houſes, or upon walls more elevated than the height to which butterflies generally riſe. What M. de Peireſc ſaw himſelf, he ſhowed to many perſons of knowledge, or of curioſity, and eſtabliſhed it as an inconteſtible fact,

that

that the pretended drops of blood were, in reality, drops of a red liquor depofited by butterflies.

To the fame caufe M. de Peirefc attributes fome other fhowers of blood related by hiftorians; and it is worthy of remark, that all of them are faid to have happened in the warm feafons of the year, when butterflies are moft numerous. Among others, Gregory of Tours mentions a fhower of blood which fell, in the time of Childebert, in different parts of Paris, and upon a certain houfe in the territory of Senlis; and, about the end of the month of June, another likewife fell under the reign of King Robert.

M. de Reaumur remarks, that almoft all the butterflies which proceeded from different fpecies of hairy caterpillars in his poffeffion, voided at leaft one, and often feveral large drops of excrement, which had the colour of blood. The hairy caterpillar that feeds upon the leaves of the elm-tree, after its transformation, emits drops, the colour of which is of a more deep red than that of blood; and, after being dried, their colour approaches to that of carmine. From another caterpillar of the elm, which is larger, and much more common than the former, proceeds a butterfly, that, immediately after its transformation, emits a great quantity of red excrement. This fpecies of caterpillar, in particular years, is fo numerous, that it lays bare the whole trees in certain diftricts. Myriads of them are transformed into chryfalids about the end of May or beginning of June. When about to undergo their metamorphofis, they often attach themfelves to the walls, and even enter into the country houfes. If thefe butterflies were all brought forth at the fame time, and flew in the fame direction, their number would be fufficient to form fmall clouds, to cover the ftones, &c. of particular diftricts with blood-coloured fpots, and to convince thofe who wifh to fright themfelves, and to fee prodigies, that a fhower of blood had fallen during the night,

night. Some of thofe hairy caterpillars which live in fociety upon nettles, likewife emit an excrementitious matter of a red colour. A thoufand examples of the fame kind might be enumerated. Hence the notion of miraculous or portentous fhowers of blood fhould be forever banifhed from the minds of men.

I would not have faid fo much upon this fubject, if I had not confidered it to be the duty of every man, when it is in his power, to remove popular prejudices, efpecially when they have a direct tendency to terrify the minds of men, and to cherifh ignorance and fuperftition.

We not only read of fhowers, but, what feems to be more unaccountable, of fountains running occafionally with blood inftead of water. Sir David Dalrymple, one of the Senators of the College of Juftice in Scotland, a gentleman not more diftinguifhed by his learning and deep refearch, than by his fcrupulous integrity and propriety of conduct, relates, in his Annals of Scotland *, upon the authority of Hoveden and Benedictus Abbas, that, in the year 1184, 'A fountain near Kilwinning †, in the fhire of Air, ran blood for 'eight days and eight nights without intermiffion. This portent 'had frequently appeared, but never for fo long a fpace. In the 'opinion of the people of the country, it prognofticated the effufion 'of blood. Benedictus Abbas, and R. Hoveden, relate the ftory of 'this portent with perfect credulity. Benedictus Abbas improves a 'little upon his brother; for he is pofitive that the fountain flowed 'with *pure* blood.' If Kilwinning, like Aix, had poffeffed fuch a philofopher as Peirefc, the rednefs of the water, if ever it did appear, would have received a moft fatisfactory explanation.

Transformations

* Vol. 1. page 298.

† A Scottifh village.

Transformations are not peculiar to animals. All *organized bodies* paſs through ſucceſſive changes. Plants, of courſe, are not exempted from mutation. What an amazing difference between an acorn and a ſtately oak? The ſeeds of plants may be compared to the chryſalids of butterflies. The ſeed, like the chryſalis, contains, in miniature, all the parts of the future plant. Theſe parts require only time, and other circumſtances neceſſary to vegetation, for their complete evolution. How different are the ſeed-leaves from thoſe of the plume? Beſide the general changes ariſing from growth, plants undergo a number of metamorphoſes from other cauſes. In northern climates, if we except a few evergreens, trees, during winter, are entirely ſtripped of their leaves. Inſtead of the pleaſant emotions excited by the variety of figures, movements, colours, and fragrance of the leaves, flowers, and fruit, during the ſpring and ſummer, nothing is exhibited in winter but the bare ſtems and branches. In this ſtate, the trees of the foreſt have a lugubrious appearance, and remind us of death and of ſkeletons. Very different are the emotions we feel in the ſpring, when the buds begin to burſt, and the leaves to expand. When ſummer approaches, another beautiful change takes place. The flowers, with all their ſplendour of colours, and ſweetneſs of flavours, are then highly delightful to our ſenſes. After performing the office of cheriſhing and protecting the tender fruit for ſome time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruit appear, and gradually grow to maturity, perpetually preſenting varieties in their magnitude, colour, odour, and flavour. When the fruit or ſeeds are fully ripe, they are gathered for the uſe of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to ſhed, winter commences, and the ſame ſeries of metamorphoſes go on during the exiſtence of the plant.

The changes juſt now mentioned are annual, and are ultimately intended to ſupply men and other animals with food. But plants are ſubjected to changes of form from cauſes of a more accidental nature. Varieties or changes in the figure of plants are often produced by ſoil, by ſituation, by culture, and by climate.

A plant is compoſed of the bark, the liber or inner circle, the wood, and the pith. The calyx or cup, the carolla or flower leaves, the ſtamina, and piſtils, are only expanſions of the bark, the liber, the wood, and the pith. The petals of all flowers, in a natural ſtate, are ſingle. But, when tranſplanted into gardens, many of them, eſpecially thoſe which are furniſhed with numerous ſtamina, as the anemone, the poppy, the peony, the ranunculus, the daiſy, the marigold, the roſe, &c. double, or rather multiply their flower-leaves without end. This change from ſingle to double, or monſtrous flowers, as they are called, is produced by too great a quantity of nutricious juices, which prevents the ſubſtance of the liber from condenſing into wood, and transforms the ſtamina into petals; and it not unfrequently happens, that, when theſe double flowering plants are committed to a poor ſoil, they become drier, are reduced to their natural ſtate, and produce ſingle flowers only. Plants which inhabit the valleys, when tranſported to the tops of mountains, or other elevated ſituations, not only become dwarfiſh, but undergo ſuch changes in their general ſtructure and appearance, that they are often thought to belong to a different ſpecies, though they are, in reality, only varieties of the ſame. Similar changes are produced when Alpine or mountain plants are cultivated in the valleys.

From culture and climate, likewiſe, plants undergo many changes. But this ſubject is ſo generally known, that to enlarge upon it would be entirely ſuperfluous. We ſhall only remark, that the older botaniſts, when they perceived the ſame ſpecies of plants growing

ing in a different ſoil, or in a different climate, aſſume ſuch different appearances, conſidered and enumerated them as diſtinct ſpecies. But the modern botaniſts, to prevent the unneceſſary multiplication of ſeparate beings, have endeavoured to reduce all thoſe varieties ariſing from fortuitous circumſtances to their original ſpecies.

From theſe facts, and many others which might be mentioned, it appears, that, in both the animal and vegetable kingdoms, forms are perpetually changing. The mineral kingdom is not leſs ſubject to metamorphoſes; but theſe belong not to our preſent ſubject. Though forms continually change, the quantity of matter is invariable. The ſame ſubſtances paſs ſucceſſively into the three kingdoms, and conſtitute, in their turn, a mineral, a plant, an inſect, a reptile, a fiſh, a bird, a quadruped, a man. In theſe transformations, organized bodies are the principal agents. They change or decompoſe every ſubſtance that either enters into them, or is expoſed to the action of their powers. Some they aſſimulate, by the proceſs of nutrition, into their own ſubſtance; others they evacuate in different forms; and theſe evacuations make ingredients in the compoſitions of other bodies, as thoſe of inſects, whoſe multiplication is prodigious, and affords a very great quantity of organized matter for the nouriſhment and ſupport of almoſt every animated being. Thus, from the apparently vileſt and moſt contemptible ſpecies of matter, the richeſt productions derive their origin. The moſt beautiful flowers, the moſt exquiſite fruits, and the moſt uſeful grain, all proceed from the boſom of corruption. The earth is continually beſtowing freſh gifts upon us; and her powers would ſoon be exhauſted, if what ſhe perpetually gives were not perpetually reſtored to her. It is a law of Nature, that all organized bodies ſhould be decompoſed, and gradually transformed into earth. While undergoing this ſpecies of diſſolution, their more volatile particles paſs into the air, and are diffuſed through the atmoſphere. Thus animals, at leaſt portions of

 them,

them, are buried in the air, as well as in the earth, or in water. Thefe floating particles foon enter into the compofition of new organized beings, who are themfelves deftined to undergo the fame revolutions. This circulation of organized matter has continued fince the commencement of the world, and will proceed in the fame courfe till its final deftruction.

With regard to the intentions of Nature in changing forms, a complete inveftigation of them exceeds the powers of human refearch. One great intention, from the examples above enumerated, cannot efcape obfervation. In the animal world, every fucceffive change is a new approach to the perfection of the individuals. Men, and the larger animals, fome time after the age of puberty, remain ftationary, and continue to multiply their fpecies for periods proportioned to their refpective fpecies. When thofe periods terminate, they gradually decay till their final diffolution. The fame obfervation is applicable to the infect tribes, whofe transformations ftrike us with wonder. The caterpillar repeatedly moults or cafts off its fkin. The butterfly exifted originally in the body of the caterpillar; but the organs of the fly were too foft, and not fufficiently unfolded. It remains unfit to encounter the open air, or to perform the functions of a perfect animal, till fome time after its transformation into a chryfalis. It then burfts through its envelope, arrives at a ftate of perfection, multiplies its fpecies, and dies. All the changes in the vegetable kingdom tend to the fame point. In the procefs of growing, they are perpetually changing forms till they produce fruit, and then they decay. Some plants, like caterpillars, go through all their transformations, death not excepted, in one year. But others, like man and the larger animals, befide the common changes produced by growth and the evolution of different organs, continue for many years in a ftate of perfection before the periods of decay and of diffolution arrive. But thefe perennial plants undergo, every year,

all

all the viciſſitudes of the annuals. They every year increaſe in magnitude, ſend forth new leaves and branches, ripen and diſſeminate their ſeeds, and, during winter, remain in a torpid ſtate, or ſuffer a temporary death. Theſe annual changes in trees, &c. have ſome reſemblance to thoſe of animals which produce at certain ſtated ſeaſons only.

The diſtribution of life to an immenſity of ſucceſſive individuals ſeems to be another intention of Nature in changing forms, and in the diſſolution of her productions. Were the exiſtence of individuals perpetual, or were it prolonged for ten times the periods now eſtabliſhed, life would be denied to myriads of animated beings, who enjoy their preſent limited portion of happineſs.

CHAP.

CHAPTER XIII.

Of the Habitations of Animals.

MANY animals, as well as thofe of the human fpecies, are endowed by Nature with an architectonic faculty. This faculty is beftowed upon them for a number of wife and ufeful purpofes. It enables them to conftruct proper habitations for concealing themfelves, for defending them againft the attacks of their enemies, for fheltering and cherifhing their young, and for protecting them from the injuries of the weather.

All animals of the fame fpecies, when not reftrained by accidental caufes, uniformly build in the fame ftyle, and ufe the fame materials. From this general rule man is to be excepted. Poffeffed of a fuperior number of inftincts, of which the reafoning faculty is a refult *, he can build in any ftyle, and employ fuch materials as his tafte, his fancy, or the purpofes for which the fabric is intended, fhall direct him. A cottage or a palace are equally within the reach of his powers. In treating of this fubject, we mean not to trace the progrefs

* See Chap. V. Of Inftinct.

progrefs of human architecture, which, in the earlier ftages of fociety, is extremely rude, but to confine ourfelves to that of the inferior tribes of animated beings.

With regard to *Quadrupeds*, many of them employ no kind of architecture, but live continually, and bring forth their young, in the open air. When not under the immediate protection of man, thefe fpecies, in rough or ftormy weather, fhelter themfelves among trees or bufhes, retire under the coverture of projecting rocks, or the fides of hills oppofite to thofe from which the wind proceeds. Befide thefe arts of defence, to which the creatures are prompted by inftinct and experience, Nature furnifhes them, during the winter months, with a double portion of long hair, which protects them from cold, and other affaults of the weather.

Of the quadrupeds that make or choofe habitations for themfelves, fome dig holes in the earth, fome take refuge in the cavities of decayed trees, and in the clefts of rocks, and fome actually conftruct cabins or houfes. But the artifices they employ, the materials they ufe, and the fituations they felect, are fo various, and fo numerous, that our plan neceffarily limits us to a few of the more curious examples.

The Alpine marmot is a quadruped about fixteen inches in length, and has a fhort tail. In figure, the marmots have fome refemblance both to the rat and to the bear. When tamed, they eat every thing prefented to them, as flefh, bread, fruit, roots, pot-herbs, infects, &c. They delight in the regions of froft and of fnow, and are only to be found on the tops of the higheft mountains. Thefe animals remain in a torpid ftate during winter. About the end of September or the beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed

with

with much art and precaution. With their feet and claws, which are admirably adapted to the purpofe, they dig the earth with amazing quicknefs, and throw it behind them. They do not make a fimple hole, or a ftraight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment, where feveral of the animals lodge together. As the whole operation is performed on the declivity of a mountain, this innermoft apartment is alone horizontal. Both branches of the Y are inclined. One of the branches defcends under the apartment, and follows the declivity of the mountain. This branch is a kind of aqueduct, and receives and carries off the excrements of the animals; and the other, which rifes above the principal apartment, is ufed for coming in and going out. The place of their abode is well lined with mofs and hay, of which they lay up great ftore during the fummer. They are focial animals. Several of them live together, and work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them ftands centinel upon a rock, while the others gambol upon the grafs, or are employed in cutting it, in order to make hay. If the centinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whiftle, and is himfelf the laft that enters the hole. As they continue torpid during winter, and, as if they forefaw that they would then have no occafion for victuals, they lay up no provifions in their apartments. But, when they feel the firft approaches of the fleeping feafon, they fhut up both paffages to their habitation; and this operation they perform with fuch labour and folidity, that it is more eafy to dig the earth any where elfe than in fuch parts as they have thus fortified. At this time they are very fat, weighing fometimes twenty pounds. They continue to be plump for three months; but afterwards they gradually decline, and, at the end of winter, they are extremely emaciated. When feized in their retreats, they appear

rolled

rolled up in the form of a ball, and covered with hay. In this ſtate, they are ſo torpid that they may be killed without ſeeming to feel pain. The hunters ſelect the fatteſt for eating, and keep the young ones for taming. Like the dormice, and all the other animals which ſleep during winter, the marmots are revived by a gradual and gentle heat: And it is remarkable, that thoſe which are fed in houſes, and kept warm, never become torpid, but are equally active and lively during the whole year.

We ſhall now give a ſhort account of the operations and architecture of the *beaver*. This amphibious quadruped is about three feet in length, and its tail, which is of an oval figure, and covered with ſcales, is eleven inches long. He uſes his tail as a rudder to direct his courſe in the water. In places much frequented by man, the beavers neither aſſociate nor build habitations. But, in the northern regions of both Continents, they aſſemble in the month of June or July, for the purpoſes of uniting into ſociety and of building a city. From all quarters they arrive in numbers, and ſoon form a troop of two or three hundred. The operations and architecture of the beavers are ſo well deſcribed by the Count de Buffon, that we ſhall lay it before our readers nearly in his own words. The place of rendezvous, he remarks, is generally the ſituation fixed upon for their eſtabliſhment, and it is always on the banks of waters. If the waters be flat, and ſeldom riſe above their ordinary level, as in lakes, the beavers make no bank or dam. But in rivers or brooks, where the water is ſubject to riſings and fallings, they build a bank, which traverſes the river from one ſide to the other, like a ſluice, and is often from 80 to 100 feet long, by 10 or 12 broad at the baſe. This pile, for animals of ſo ſmall a ſize, appears to be enormous, and preſuppoſes an incredible labour *. But the ſolidity with

* The largeſt beavers weigh only 50 or 60 pounds.

which the work is conſtructed is ſtill more aſtoniſhing than its magnitude. The part of the river where they erect this bank is generally ſhallow. If they find on the margin a large tree, which can be made to fall into the river, they begin, by cutting it down, to form the principal baſis of their work. This tree is often thicker than a man's body. By gnawing it at the bottom with their four cutting teeth, they in a ſhort time accompliſh their purpoſe, and always make the tree fall acroſs the river. They next cut the branches from the trunk to make it lie level. Theſe operations are performed by the joint induſtry of the whole community. Some of them, at the ſame time, traverſe the banks of the river, and cut down ſmaller trees, from the ſize of a man's leg to that of his thigh. Theſe they cut to a certain length, dreſs them into ſtakes, and firſt drag them by land to the margin of the river, and then by water to the place where the building is carrying on. Theſe piles they ſink down, and interweave the branches with the larger ſtakes. In performing this operation many difficulties are to be ſurmounted. In order to dreſs theſe ſtakes, and to put them in a ſituation nearly perpendicular, ſome of the beavers muſt elevate, with their teeth, the thick ends againſt the margin of the river, or againſt the croſs tree, while others plunge to the bottom, and dig holes with their fore-feet to receive the points, that they may ſtand on end. When ſome are labouring in this manner, others bring earth, which they plaſh with their feet, and beat firm with their tails. They carry the earth in their mouths, and with their fore-feet. They tranſport earth in ſuch quantities, that they fill with it all the intervals between the piles. Theſe piles conſiſt of ſeveral rows of ſtakes, of equal height, all placed oppoſite to each other, and extend from one bank of the river to the other. The ſtakes facing the under part of the river are placed perpendicularly; but thoſe which are oppoſed to the ſtream ſlope upward to ſuſtain the preſſure of the water; ſo that the bank, which is ten or twelve feet wide at the baſe, is reduced to two or three at the top. Near the top, or thinneſt thinneft part of the bank, the beavers make two or three floping holes, to allow the furface-water to efcape. Thefe they enlarge or contract in proportion as the river rifes or falls; and, when any breaches are made in the bank by fudden or violent inundations, they know how to repair them when the water fubfides.

Hitherto all thefe operations were performed by the united force and dexterity of the whole community. They now feparate into fmaller focieties, who build cabins or houfes. Thefe cabins are conftructed upon piles near the margin of the river or pond, and have two openings, one for the animals going to the land, and the other for throwing themfelves into the water. The form of thefe edifices is either round or oval, and they vary in fize from four or five to eight or ten feet in diameter. Some of them confift of three or four ftories. Their walls are about two feet thick; and are raifed perpendicularly upon planks, or plain ftakes, which ferve both for foundations and floors to their houfes. When they confift of but one ftory, they rife perpendicularly a few feet only, afterwards affume a curved form, and terminate in a dome or vault, which anfwers the purpofe of a roof. They are built with amazing folidity, and neatly plaftered with a kind of ftucco both within and without. In the application of this mortar the tails of the beavers ferve for trowels, and their feet for plafhing. Their houfes are impenetrable to rain, and refift the moft impetuous winds. In their conftruction, they employ different materials, as wood, ftone, and a kind of fandy earth, which is not liable to be diffolved in water. The wood they ufe is generally of the light and tender kinds, as alders, poplars, and willows, which commonly grow on the banks of rivers, and are more eafily barked, cut, and tranfported, than the heavier and more folid fpecies of timber. They always begin the operation of cutting trees at a foot or a foot and a half above the ground: They labour in a fitting pofture; and, befide the convenience of this pofture, they enjoy the pleafure of gnawing perpetually the bark and wood, which are their favourite food. Of theſe proviſions they lay up ample ſtores in their cabins to ſupport them during the winter. Each cabin has its own magazine, which is proportioned to the number of its inhabitants, who have all a common right to the ſtore, and never pillage their neighbours. Some villages are compoſed of twenty or twenty-five cabins. But theſe large eſtabliſhments are not frequent; and the common republics ſeldom exceed ten or twelve families, of which each have their own quarter of the village, their own magazine, and their ſeparate habitation. The ſmalleſt cabins contain two, four, or ſix, and the largeſt eighteen, twenty, and ſometimes thirty beavers. As to males and females, they are almoſt always equally paired. Upon a moderate computation, therefore, the ſociety is often compoſed of 150 or 200, who all, at firſt, labour jointly in raiſing the great public building, and afterwards, in ſelect tribes or companies, in making particular habitations. In this ſociety, however numerous, an univerſal peace is maintained. Their union is cemented by common labours; and it is perpetuated by mutual conveniency, and the abundance of proviſions which they amaſs and conſume together. A ſimple taſte, moderate appetites, and an averſion to blood and carnage, render them deſtitute of the ideas of rapine and of war. Friends to each other, if they have any foreign enemies they know how to avoid them. When danger approaches, they advertiſe one another, by ſtriking their broad tail on the ſurface of the water, the noiſe of which is heard at a great diſtance, and reſounds through all the vaults of their habitations. Each individual, upon theſe occaſions, conſults his own ſafety; ſome plunge into the water; others conceal themſelves within their walls, which can be penetrated only by the fire of heaven, or the ſteel of man, and which no animal will attempt either to open or to overturn. Theſe retreats are not only ſafe, but neat and commodious. The floors are ſpread over with verdure: The branches of the box and of the fir ſerve them for

carpets,

carpets, upon which they permit not the ſmalleſt dirtineſs. The window that faces the water anſwers for a balcony to receive the freſh air, and for the purpoſe of bathing. During the greater part of the day, the beavers ſit on end, with their head and the anterior parts of their body elevated, and their poſterior parts ſunk in the water. The aperture of this window is ſufficiently raiſed to prevent its being ſtopped up with the ice, which, in the beaver climates, is often two or three feet thick. When this accident happens, they ſlope the ſole of the window, cut obliquely the ſtakes which ſupport it, and thus open a communication with the unfrozen water. They often ſwim a long way under the ice. The continual habit of keeping their tail and poſterior parts of their body in the water, appears to have changed the nature of their fleſh ; for that of their anterior parts, as far as the reins, has the taſte and conſiſtence of the fleſh of land-animals ; but that of the tail and poſterior parts has the odour and all the other qualities of fiſh. The tail, which is a foot long, an inch thick, and five or ſix inches broad, is a genuine portion of a fiſh attached to the body of a quadruped : It is wholly covered with ſcales, and below the ſcales with a ſkin perfectly ſimilar to that of large fiſhes. In September, the beavers collect their proviſions of bark and of wood. Till the end of winter, they remain in their cabins, enjoy the fruits of their labours, and taſte the ſweets of domeſtic happineſs. This is their time of repoſe, and their ſeaſon of love. Knowing and loving one another, each couple unite, not by chance, but by taſte and a real ſelection. The females bring forth in the end of winter, and generally produce two or three at a time. About this period they are left by the males, who retire to the country to enjoy the pleaſures and the fruits of the ſpring. They return occaſionally, however, to their cabins ; but dwell there no more. The mothers continue in the cabins, and are occupied in nurſing, protecting, and rearing their young, which in a few weeks are in a condition to follow their dams. The beavers aſſemble not again till

autumn,

autumn, unlefs their banks or cabins be injured by inundations; for, when accidents of this kind happen, they fuddenly collect their forces, and repair the breaches that have been made.

This account of the fociety and operations of beavers, however marvellous it may appear, has been eftablifhed and confirmed by fo many credible eye-witneffes, that it is impoffible to doubt of its reality.

The habitation where *moles* depofit their young merits a particular defcription; becaufe it is conftructed with peculiar intelligence, and becaufe the mole is an animal with which we are well acquainted. They begin by raifing the earth, and forming a pretty high arch. They leave partitions, or a kind of pillars, at certain diftances, beat and prefs the earth, interweave it with the roots of plants, and render it fo hard and folid, that the water cannot penetrate the vault, on account of its convexity and firmnefs. They then elevate a little hillock under the principal arch; upon the latter they lay herbs and leaves for a bed to their young. In this fituation they are above the level of the ground, and, of courfe, beyond the reach of ordinary inundations. They are, at the fame time, defended from the rains by the large vault that covers the internal one, upon the convexity of which laft they reft along with their young. This internal hillock is pierced on all fides with floping holes, which defcend ftill lower, and ferve as fubterraneous paffages for the mother to go in queft of food for herfelf and her offspring. Thefe by-paths are beaten and firm, extend about twelve or fifteen paces, and iffue from the principal manfion like rays from a centre. Under the fuperior vault we likewife find remains of the roots of the meadow faffron, which feem to be the firft food given to the young. From this defcription it appears, that the mole never comes abroad but at confiderable diftances from her habitation. Moles, like the beavers, pair; and fo lively and reciprocal an attachment fubfifts between them, that

that they ſeem to diſreliſh all other ſociety. In their dark abodes they enjoy the placid habits of repoſe and of ſolitude, the art of ſecuring themſelves from injury, of almoſt inſtantaneouſly making an aſylum or habitation, and of procuring a plentiful ſubſiſtence without the neceſſity of going abroad. They ſhut up the entrance of their retreats, and ſeldom leave them, unleſs compelled by the admiſſion of water, or when their manſions are demoliſhed by art.

The nidification of *Birds* has at all times deſervedly called forth the admiration of mankind. In general, the neſts of birds are built with an art ſo exquiſite, that an exact imitation of them exceeds all the powers of human ſkill and induſtry. Their ſtyle of architecture, the materials they employ, and the ſituations they ſelect, are as various as the different ſpecies. Individuals of the ſame ſpecies, whatever region of the globe they inhabit, collect the ſame materials, arrange and conſtruct them in the ſame form, and make choice of ſimilar ſituations for erecting their temporary habitations; for the neſts of birds, thoſe of the eagle-kind excepted, after the young have come to maturity, are forever abandoned by the parents.

To deſcribe minutely the neſts of birds would be a vain attempt. Such deſcriptions could not convey an adequate idea of their architecture to a perſon who had never ſeen one of thoſe beautiful and commodious habitations, which even aſtoniſh and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and ſtructure of their neſts. Thoſe of the rapacious tribes are in general rude, and compoſed of courſe materials, as dried twigs, bents, &c. But they are often lined with ſoft ſubſtances. They build in elevated rocks, ruinous and ſequeſtered caſtles and towers, and in other ſolitary retirements. The aiery or neſt of the

eagle

eagle is quite flat, and not hollow, like thofe of other birds. The male and female commonly place their neft between two rocks, in a dry and inacceffible fituation. The fame neft, it is faid, ferves the eagle during life. The ftructure is fo confiderable, and compofed of fuch folid materials, that it may laft many years. Its form refembles that of a floor. Its bafis confifts of fticks about five or fix feet in length, which are fupported at each end, and thefe are covered with feveral layers of rufhes and heath. An eagle's neft was found in the Peak of Derbyfhire, which Willoughby defcribes in the following manner: 'It was made of great fticks, refting one end 'on the edge of a rock, the other on a birch tree. Upon thefe was 'a layer of rufhes, and over them a layer of heath, and on the 'heath rufhes again; upon which lay one young, and an addle egg; 'and by them a lamb, a hare, and three heath pouts. The neft was 'about two yards fquare, and had no hollow in it.' But the butcher-birds, or fhrikes, which are lefs rapacious than eagles and hawks, build their habitations in fhrubs and bufhes, and employ mofs, wool, and other foft materials.

The birds belonging to the order of *Pies* in the ingenious Mr Pennant's Genera of Birds, are extremely irregular in conftructing their nefts. The common magpies build their nefts in trees, and their ftructure is admirably contrived for affording warmth and protection to the young. The neft is not open at top: It is covered, in the moft dexterous manner, with an arch or dome, and a fmall opening in the fide of it is left, to give the parents an opportunity of paffing in and out at their pleafure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external furface of their neft, fharp briars and thorns. The long-tailed titmoufe, or ox-eye, builds nearly like the wren, but with ftill greater art. With the fame materials as the reft of the ftructure, the titmoufe builds an arch over the top of the neft, which

refembles

refembles an egg erected upon one end, and leaves a fmall hole in the fide for a paffage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young may have a foft and warm bed, fhe lines the infide of the neft with feathers, down, and cobwebs. The fides and roof are compofed of mofs and wool interwoven in the moft curious and artificial manner.

In treating of inftinct, it was mentioned, that, in warm climates, many fmall birds fufpended their nefts on tender twigs of trees, to prevent them from being deftroyed by the monkeys. In Europe, there are only three birds which build penfile nefts, namely, the common oriola, the *parus pendulinus*, or hang-neft titmoufe; and another penfile neft, belonging to fome unknown bird, was lately difcovered by Mr Pennant, near the houfe of Blair in Athole, in the north of Scotland. ‘ In a fpruce fir-tree,’ Mr Pennant remarks, ‘ was a hang-neft of fome unknown bird, fufpended at the four cor- ‘ ners to the boughs. It was open at top, an inch and a half dia- ‘ meter, and two deep; the fides and bottom thick; the materials ‘ mofs, worfted, and birch bark, lined with feathers *.’

Mr Pennant, in his Indian Zoology, gives the following curious account of the manner in which the motacilla futoria, or taylor bird, builds its neft. ‘ Had providence,’ Mr Pennant remarks, ‘ left ‘ the feathered tribes unendowed with any particular inftinct, the ‘ birds of the torrid zone would have built their nefts in the fame ‘ unguarded manner as thofe of Europe; but there the leffer fpecies, ‘ having a certain prefcience of the dangers that furround them, and ‘ of their own weaknefs, fufpend their nefts at the extreme branches ‘ of the trees: They are confcious of inhabiting a climate replete ‘ with enemies to them and their young; with fnakes that twine up

† S f ‘ the

* Pennant's Tour, vol. 1. pag. 104. 3d edit.

'the bodies of the trees, and apes that are perpetually in ſearch of 'prey; but, heaven-inſtructed, they elude the gliding of the one, 'and the activity of the other.—The brute creation are more at 'enmity with one another than in other climates; and the birds 'are obliged to exert an unuſual artifice in placing their little broods 'out of the reach of an invader. Each aims at the ſame end, though 'by different means; ſome form their penſile neſt in ſhape of a 'purſe, deep and open at top, others with a hole in the ſide, and 'others, ſtill more cautious, with an entrance at the very bottom, 'forming their lodge near the ſummit *. But the taylor-bird ſeems 'to have greater diffidence than any of the others: It will not truſt 'its neſt even to the extremity of a ſlender twig, but makes one 'more advance to ſafety by fixing it to the leaf itſelf. It picks up 'a dead leaf, and, ſurpriſing to relate, ſews it to the ſide of a living 'one †, its ſlender bill being its needle, and its thread ſome fine 'fibres, the lining feathers, goſſamer, and down. Its eggs are white, 'the colour of the bird light yellow; its length three inches; its 'weight only three ſixteenths of an ounce; ſo that the materials of 'the neſt, and its own ſize, are not likely to draw down a habita- 'tion that depends on ſo ſlight a tenure ‡.'

Birds of the gallinaceous or poultry kind lay their eggs on the ground. Some of them ſcrape a kind of hole in the earth, and line it with a little long graſs or ſtraw.

It

* This inſtinct prevails alſo among the birds on the banks of the Gambia, in Africa, which abounds with monkeys and ſnakes; others, for the ſame end, make their neſt in holes of the banks that overhang that vaſt river; Purchas, vol. 2. pag. 1576.

† A neſt of this bird is preſerved in the Britiſh Muſaeum.

‡ Pennant's Indian Zoology, pag. 7.

It is a ſingular, though a well atteſted fact, that the cuckow makes no neſt, and neither hatches nor feeds her own young. 'The hedge-'ſparrow,' ſays Mr Willoughby, 'is the cuckow's nurſe, but not 'the hedge-ſparrow only, but alſo ring-doves, larks, finches. I 'myſelf, with many others, have ſeen a wag-tail feeding a young 'cuckow. The cuckow herſelf builds no neſt; but having found 'the neſt of ſome little bird, ſhe either devours or deſtroys the eggs 'ſhe there finds, and, in the room thereof, lays one of her own, and 'ſo forſakes it. The ſilly bird returning, ſits on this egg, hatches 'it, and, with a great deal of care and toil, broods, feeds, and che-'riſhes the young cuckow for her own, until it be grown up and 'able to fly and ſhift for itſelf. Which thing ſeems ſo ſtrange, 'monſtrous, and abſurd, that for my part I cannot ſufficiently won-'der there ſhould be ſuch an example in Nature; nor could I ever 'have been induced to believe that ſuch a thing had been done by 'Nature's inſtinct, had I not with mine own eyes ſeen it. For Na-'ture, in other things, is wont conſtantly to obſerve one and the 'ſame law and order, agreeable to the higheſt reaſon and prudence; 'which in this caſe is, that the dams make neſts for themſelves, if 'need be, ſit upon their own eggs, and bring up their own young 'after they are hatched *.' This oeconomy, in the hiſtory of the cuckow, is not only ſingular, but ſeems to contradict one of the moſt univerſal laws eſtabliſhed among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the oſtrich in very warm climates, though the cuckow neither hatches nor feeds her young, ſhe places her eggs in ſituations where they are both hatched and her offspring brought to maturity. Here the ſtupidity of the one animal makes it a dupe to the rapine and chicane of the other; for the cuckow always deſtroys the eggs of the ſmall bird before ſhe depoſits her own.

* Willoughby's Ornithology, pag. 98.

Moſt of the paſſerine or ſmall tribes build their neſts in hedges, ſhrubs, or buſhes; though ſome of them, as the lark and the goat-ſucker, build upon the ground. The neſts of ſmall birds are more delicate in their ſtructure and contrivance than thoſe of the larger kinds. As the ſize of their bodies, and likewiſe that of their eggs, are ſmaller, the materials of which their neſts are compoſed are generally warmer. Small bodies retain heat a ſhorter time than thoſe which are large. Hence the eggs of ſmall birds require a more conſtant ſupply of heat than thoſe of greater dimenſions. Their neſts, accordingly, are built proportionally warmer and deeper, and they are lined with ſofter ſubſtances. The larger birds, of courſe, can leave their eggs for ſome time with impunity; but the ſmaller kinds ſit moſt aſſiduouſly; for, when the female is obliged to go abroad in queſt of food, the neſt is always occupied by the male. When a neſt is finiſhed, nothing can exceed the dexterity of both male and female in concealing it from the obſervation of man, and of other deſtructive animals. If it is built in buſhes, the pliant branches are diſpoſed in ſuch a manner as to hide it entirely from view. To conceal her retreat, the chaffinch covers the outſide of her neſt with moſs, which is commonly of the ſame colour with the bark of the tree on which ſhe builds. The common ſwallow builds its neſt on the tops of chimneys; and the martin attaches hers to the corners of windows, or under the eaves of houſes. Both employ the ſame materials. The neſt is built with mud well tempered by the bill, and moiſtened with water to make it more firmly cohere; and the mud or clay is kept ſtill firmer by a mixture of ſtraw or graſs. Within it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, ‘ That, on the ſea coſt of the king-‘ dom of China, a ſort of ſmall party-coloured birds, of the ſhape ‘ of ſwallows, at a certain ſeaſon of the year, viz. their breeding ‘ time, come out of the midland country to the rocks; and from ‘ the foam or froth of the ſea-water daſhing and breaking againſt 'the bottom of the rocks, gather a certain clammy, glutinous matter, perchance the ſperm of whales, or other fiſhes, of which they build their neſts, wherein they lay their eggs, and hatch their young. Theſe neſts the Chineſe pluck from the rocks, and bring them in great numbers into the Eaſt Indies to ſell; which are eſteemed by gluttons great delicacies, who, diſſolving them in chicken or mutton broth, are very fond of them, preferring them far before oyſters, muſhrooms, or other dainty and lickeriſh morſels which moſt gratify the palate.—Theſe neſts are of a hemiſpherical figure, of the bigneſs of a gooſe-egg, and of a ſubſtance reſembling iſing-glaſs *.'

Moſt of the cloven-footed water-fowls, or waders, lay their eggs upon the ground. But the ſpoon-bills and the common heron build large neſts in trees, and employ twigs and other coarſe materials; and the ſtorks build on churches, or on the tops of houſes. Many of the web-footed fowls lay their eggs likewiſe on the ground, as the terns, and ſome of the gulls and merganſers. But ducks pull the down from their own breaſts to afford a warmer and more comfortable bed for their young. The auks, the guillemots, and the puffins or coulternebs, lay their eggs on the naked ſhelves of high rocks. The penguins, for the ſame purpoſe, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimenſions of their neſts to the number and ſize of the young to be produced. Every ſpecies lays nearly a determined number of eggs. But, if one be each day abſtracted from the neſt, the bird continues to lay daily more till her number is completed. Dr Liſter, by this practice, made a ſwallow lay no leſs than nineteen eggs.

The

* Willoughby's Ornithology, pag. 215.

The habitations of *Infects* are next to be confidered. On this branch of the fubject, we fhall firft give fome examples of abodes conftructed by folitary workers, and next of thofe habitations which are executed by affociated numbers.

In feveral preceding parts of this work, and particularly in the chapter upon Inftinct, the reader will find fome inftances of the fkill and induftry exhibited by infects for the convenient lodging and protection of their young. Thefe it is unneceffary to repeat. We fhall therefore proceed to give fome examples of a different kind.

There are feveral fpecies of bees diftinguifhed by the appellation of *folitary*, becaufe they do not affociate to carry on any joint operations. Of this kind is the *mafon-bee*, fo called becaufe it builds a habitation compofed of fand and mortar. The nefts of this bee are fixed to the walls of houfes, and, when finifhed, have the appearance of irregular prominences arifing from dirt or clay accidentally thrown againft a wall or ftone by the feet of horfes. Thefe prominencies are not fo remarkable as to attract attention ; but, when the external coat is removed, their ftructure is difcovered to be truly admirable. The interior part confifts of an affemblage of different cells, each of which affords a convenient lodgement to a white worm, pretty fimilar to thofe produced by the honey-bee. Here they remain till they have undergone all their metamorphofes. In conftructing this neft, which is a work of great labour and dexterity, the female is the fole operator. She receives no affiftance from the male. The manner in which the female mafon-bees build their nefts is the moft curious branch of their hiftory.

After choofing a part of a wall on which fhe is refolved to fix an habitation for her future progeny, fhe goes in queft of proper materials. The neft to be conftructed muft confift of a fpecies of mor-

tar,

tar, of which ſand is the baſis. She knows, like human builders, that every kind of ſand is not equally proper for making good mortar. She goes, therefore, to a bed of ſand and ſelects, grain by grain, the kind which is beſt to anſwer her purpoſe. With her teeth, which are as large and as ſtrong as thoſe of the honey bee, ſhe examines and brings together ſeveral grains. But ſand alone will not make mortar. Recourſe muſt be had to a cement ſimilar to the ſlacked lime employed by maſons. Our bee is unacquainted with lime, but ſhe poſſeſſes an equivalent in her own body. From her mouth ſhe throws out a viſcid liquor, with which ſhe moiſtens the firſt grain pitched upon. To this grain ſhe cements a ſecond, which ſhe moiſtens in the ſame manner, and to the former two ſhe attaches a third, and ſo on, till ſhe has formed a maſs as large as the ſhot uſually employed to kill hares. This maſs ſhe carries off in her teeth to the place ſhe had choſen for erecting her neſt, and makes it the foundation of the firſt cell. In this manner ſhe labours inceſſantly till the whole cells are completed, a work which is generally accompliſhed in five or ſix days. All the cells are ſimilar, and nearly equal in dimenſions. Before they are covered, their figure reſembles that of a thimble. She never begins to make a ſecond till the firſt be finiſhed. Each cell is about an inch high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raiſed to one half or two thirds of its height, another occupation commences. She ſeems to know the quantity of food that will be neceſſary to nouriſh the young that is to proceed from the egg, from its excluſion till it acquires its full growth, and paſſes into the chryſalis ſtate. The food which is prepared for the ſupport of the young worm conſiſts of the farina or powder of flowers, diluted with honey, which forms a kind of pap. Before the cell is entirely finiſhed, the maſon-bee collects from the flowers, and depoſits in the cell, a large quantity of farina, and afterwards diſgorges upon it as much honey as dilutes

dilutes it, and forms it into a kind of paſte, or ſyrup. When this operation is performed, ſhe completes her cell, and, after depoſiting an egg in it, covers the mouth of it with the ſame mortar ſhe uſes in building her neſt. The egg is now incloſed on all ſides in a walled habitation hermetically ſealed. A ſmall quantity of air, however, gets admiſſion to the worm, otherwiſe it could not exiſt. Reaumur diſcovered that air actually penetrated through this ſeemingly compact maſon-work.

As ſoon as the firſt cell is completed, the maſon-bee lays the foundation of another. In the ſame neſt ſhe often conſtructs ſeven or eight cells, and ſometimes only three or four. She places them near each other, but not in any regular order. This induſtrious animal, after all her cells are conſtructed, filled with proviſions, and ſealed, covers the whole with an envelope of the ſame mortar, which, when dry, is as hard as a ſtone. The neſt now is commonly of an oblong or roundiſh figure, and the external cover is compoſed of coarſer ſand than that of the cells. As the neſts are almoſt as durable as the walls on which they are placed, they are often, in the following ſeaſon, occupied and repaired by a ſtranger bee. Though incloſed with two hard walls, when the fly emerges from the chryſalis ſtate, it firſt gnaws with its teeth a paſſage through the wall that ſealed up the mouth of its cell, afterwards, with the ſame inſtruments, it pierces the ſtill ſtronger and more compact cover which inveſts the whole neſt; at laſt it eſcapes into the open air, and, if a female, in a ſhort time, conſtructs a neſt of the ſame kind with that which the mother had made. To all theſe facts, Du Hamel, Reaumur, and many other naturaliſts of credit and reputation, have been repeatedly eye-witneſſes.

From the hardneſs of the materials with which the maſon-bee conſtructs her neſt, from the induſtry and dexterity ſhe employs to protect proteɑ her progeny from enemies of every kind, one ſhould naturally imagine that the young worms were in perfect ſafety, and that their caſtle was impregnable. But, notwithſtanding all theſe favourable precautions, the young of the maſon-bee are often devoured by the inſtinctive dexterity of certain ſpecies of four-winged inſects, diſtinguiſhed by the name of *ichneumon flies*. Theſe flies, when the maſon-bee has nearly completed a cell, and filled it with proviſions, depoſit their own eggs in her cell. After the eggs of the ichneumon flies are hatched, their worms devour not only the proviſions laid up by the maſon-bee, but even her progeny whom ſhe had laboured ſo hard, and with ſo much art and ingenuity, to protect. But the maſon-bee has an enemy ſtill more formidable. A certain fly employs the ſame ſtratagem of inſinuating an egg into one of her cells before it is completed. From this egg proceeds a ſtrong and rapacious worm, armed with prodigious fangs. The devaſtations of this worm are not confined to one cell. He often pierces through each cell in the neſt, and ſucceſſively devours both the maſon-worms, and the proviſions ſo anxiouſly laid up for their ſupport by the mother. This ſtranger worm is afterwards transformed into a fine beetle, who is enabled to pierce the neſt, and to make his eſcape.

The operations of another ſpecies of ſolitary bees, called *wood-piercers*, merit attention. Theſe bees are larger than the queens of the honey-bee. Their bodies are ſmooth, except the ſides, which are covered with hair. In the ſpring, they frequent gardens, and ſearch for rotten, or at leaſt dead wood, in order to make an habitation for their young. When a female of this ſpecies, for ſhe receives no aſſiſtance from the male, has ſelected a piece of wood, or a decayed tree, ſhe commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When ſhe has advanced about half an inch, ſhe alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The ſize of her body requires that this hole ſhould have a conſiderable diameter. It is often ſo large as to admit the finger of a man, and it ſometimes extends from twelve to fifteen inches in length. If the thickneſs of the wood permits, ſhe makes three or four of theſe long holes in its interior part. M. de Reaumur found three of theſe parallel holes in an old eſpalier poſt. Their diameters exceeded half an inch. This labour, for a ſingle bee, is prodigious; but, in executing it, ſhe conſumes weeks, and even months.

Around the foot of a poſt or piece of wood where one of theſe bees are working, little heaps of timber-duſt are always found lying on the ground. Theſe heaps daily increaſe in magnitude, and the particles of duſt are as large as thoſe produced by a hand-ſaw. The two teeth with which the animal is provided are the only inſtruments ſhe employs in making ſuch conſiderable perforations. Each tooth conſiſts of a ſolid piece of ſhell, which in ſhape reſembles an auger. It is convex above, concave below, and terminates in a ſharp but ſtrong point.

Theſe long holes are deſigned for lodgings to the worms that are to proceed from the eggs which the bee is ſoon to depoſit in them. But, after the holes are finiſhed, her labour is by no means at an end. The eggs muſt not be mingled, or piled above each other. Every ſeparate worm muſt have a diſtinct appartment, without any communication with the others. Each long hole or tube, accordingly, is only the outer walls of a houſe which is to conſiſt of many chambers ranged one above another. A hole of about twelve inches in length ſhe divides into ten or twelve ſeparate appartments, each of which is about an inch high. The roof of the loweſt room is the floor of the ſecond, and ſo on to the uppermoſt. Each floor is about the thickneſs of a French crown. The floors or diviſions are compoſed pofed of particles of wood cemented together by a glutinous fubftance from the animal's mouth. In making a floor, fhe commences with gluing an annular plate of wood-duft round the internal circumference of the cavity. To this plate fhe attaches a fecond, to the fecond a third, and to the third a fourth, till the whole floor is completed. The undermoft cell requires only a roof, and this roof is a floor to the fecond, &c.

We have hitherto defcribed the wonderful affiduity of this animal in conftructing her cells. But this operation, though great, and feemingly fuperior to the powers of a creature fo fmall, is not her only labour. Before roofing in the firft cell, fhe fills it with a pafte or pap, compofed of the farina of flowers moiftened with honey. The quantity of pafte is equal to the dimenfions of the cell, which is about an inch high, and half an inch in diameter. Into this pafte, which is to nourifh the future worm, fhe depofits an egg. Immediately after this operation, fhe begins to form a roof, which not only inclofes the firft cell, but ferves as a floor to the fecond. The fecond cell fhe likewife fills with pafte, depofits an egg, and then covers the whole with another roof. In this manner fhe proceeds, till fhe has divided the whole tube into feparate cells. A fingle tube frequently contains from ten to a dozen of thefe cells. When the cells are all inclofed, the bufinefs of this laborious bee is finifhed, and fhe takes no more charge of her future progeny. The attention and folicitude beftowed by many other animals, in rearing their young, are exerted after birth. But, in the wood-piercing bee, as well as in many other infects, this inftinctive attachment is reverfed. All her labours and all her cares are exerted before fhe either fees her offspring, or knows that they are to exift. But, after the defcription that has been given of her amazing operations, fhe will not be confidered as an unnatural mother. With aftonifhing induftry and perfeverance, fhe not only furnifhes her young with fafe and convenient lodgings, but lays up for them ſtores of proviſions ſufficient to ſupport them till their final metamorphoſis into flies, when the new females perform the ſame almoſt incredible operations for the protection and ſuſtenance of their own offspring. When the young worm is hatched, it has ſcarcely ſufficient ſpace to turn itſelf in the cell, which is almoſt entirely filled with the pappy ſubſtance formerly mentioned. But, as this ſubſtance is gradually devoured by the worm, the ſpace in the cell neceſſarily enlarges in proportion to the growth and magnitude of the animal.

We are informed by M. de Reaumur *, that M. Pitot furniſhed him with a piece of wood, not exceeding an inch and a half in diameter, which contained the cells of a wood-piercing bee. He cut off as much of the wood as was ſufficient to expoſe two of the cells to view, in each of which was a worm. The aperture he had made, to prevent the injuries of the air, he cloſed, by paſting on it a bit of glaſs. The cells were then almoſt entirely filled with paſte. The two worms were exceedingly ſmall, and, of courſe, occupied but little ſpace between the walls of the cells and the maſs of paſte. As the animals increaſed in ſize, the paſte daily diminiſhed. He began to obſerve them on the 12th day of June; and, on the 27th of the ſame month, the paſte in each cell was nearly conſumed, and the worm, folded in two, occupied the greater part of its habitation. On the 2d of July, the proviſions of both worms were entirely exhauſted; and, beſide the worms themſelves, there remained in the cells only a few ſmall, black, oblong grains of excrement. The five or ſix following days they faſted, which ſeemed to be a neceſſary abſtinence, during which they were greatly agitated. They often bended their bodies, and elevated and depreſſed their heads. Theſe movements were preparatory to the great change the animals were about

* Tom. 11. pag. 58. 12mo edit.

about to undergo. Between the 7th and 8th of the ſame month, they threw off their ſkins, and were metamorphoſed into nymphs. On the 30th of July, theſe nymphs were transformed into flies ſimilar to their parents. In a range of cells, the worms are of different ages, and, of courſe, of different ſizes. Thoſe in the lower cells are older than thoſe in the ſuperior; becauſe, after the bee has filled with paſte and encloſed its firſt cell, a conſiderable time is requiſite to collect proviſions, and to form partitions for every ſucceſſive and ſuperior cell. The former, therefore, muſt be transformed into nymphs and flies before the latter. Theſe circumſtances are apparently foreſeen by the common mother; for, if the undermoſt worm, which is oldeſt, and ſooneſt transformed, were to force its way upward, which it could eaſily do, it would not only diſturb, but infallibly deſtroy all thoſe lodged in the ſuperior cells. But Nature has wiſely prevented this devaſtation; for the head of the nymph, and conſequently of the fly, is always placed in a downward direction. Its firſt inſtinctive movements muſt, therefore, be in the ſame direction. That the young flies may eſcape from their reſpective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermoſt cell and the open air. Sometimes a ſimilar paſſage is made near the middle of the tube. By this contrivance, as all the flies inſtinctively endeavour to cut their way downward, they find an eaſy and convenient paſſage; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another ſmall ſpecies of ſolitary bees dig holes in the earth to make a convenient habitation for their young. Their neſts are compoſed of cylindrical cells fixed to one another, and each of them, in figure, reſembles a thimble. Their bottom, of courſe, is convex and rounded. The bottom of the ſecond is inſerted into the entry of the firſt; and the entry of the ſecond receives the bottom of the third. They are not all of the ſame length. Some of them are five lines long, others only four, and their diameters ſeldom exceed two lines. Sometimes only two of theſe cells are joined together; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is compoſed of alternate bands of two different colours: Thoſe of the narroweſt, at the juncture of two cells, are white, and thoſe of the broadeſt are of a reddiſh brown. The cells conſiſt of a number of fine membranes, formed of a glutinous and tranſparent ſubſtance from the animal's mouth. Each cell our bee fills with the farina of flowers diluted with honey, and in this paſte ſhe depoſits an egg. She then covers the cell, by gluing to its mouth a fine cellular ſubſtance taken from the leaves of ſome plant; and in this manner ſhe proceeds till her cylindrical neſt is completed. The worms which are hatched from the eggs feed upon the paſte, ſo carefully laid up for them by the mother, till they are transformed into flies ſimilar to their parents.

Among waſps, as well as bees, there are ſolitary ſpecies, which carry on no joint operations. Theſe ſolitary waſps are not leſs ingenious in conſtructing proper habitations for their young, nor leſs provident in laying up for them a ſtore of nouriſhment ſufficient to ſupport them till they are transformed into flies, or have become perfect animals *. But, to give a detailed deſcription of their operations would lead us into a prolixity of which the plan of our work does not admit.

On this ſubject, however, it cannot eſcape obſervation, that all the ſagacity and laborious induſtry exerted in the various inſtances of animal architecture above deſcribed, have one uniform tendency. They are all deſigned for the multiplication, protection, and nouriſhment

* See page 128.

riſhment of offspring. But many of them are ſo artful, and require ſuch perſevering labour, that the human mind is bewildered when it attempts to account for them. If we attend to the operations of quadrupeds, of birds, and of inſects, moſt of them, like pregnant women, ſeem to know, from their own feelings, and foreſight, not only their preſent condition, but what futurity is to produce. To ſolve this problem, recourſe has been had by Des Cartes, by Buffon, and by other philoſophers, to conformation of body and mechanical impulſe. Their reaſonings, however, though often ingenious, involve the ſubject in tenfold obſcurity. We can hardly ſuppoſe that the animals actually foreſee what is to happen, becauſe, at firſt, they have not had even the aid of experience; and, particularly in ſome of the inſect tribes, the parents are dead before their young are produced. Pure inſtincts of this kind, therefore, muſt be referred to another ſource. In a chain of reaſoning concerning the operations of Nature, ſuch is the conſtitution of our minds, that we are under the neceſſity of reſorting to an ultimate cauſe. What that cauſe is, it is the higheſt preſumption in man to pretend to define. But, though we muſt forever remain ignorant of the cauſe, we are enabled to trace, and even to underſtand, partially, ſome of the effects; and, from theſe effects, we perceive the moſt conſummate wiſdom, the moſt elegant and perfect contrivances to accompliſh the multifarious and wonderful intentions of Nature. In contemplating the operations of animals, from man down to the ſeemingly moſt contemptible inſect, we are neceſſarily compelled to refer them to pure inſtincts, or original qualities of mind, variegated by Nature according as the neceſſities, preſervation, and continuation of the different ſpecies require. Let any man try to proceed a ſtep farther, and, however he may deceive himſelf, and flatter his own vanity, he muſt find, at laſt, that he is clouded in obſcurity, and that men who have a more correct and unprejudiſed mode of thinking will brand him

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with abſurdity, and of acting in direct oppoſition to the conſtitution and frame of the human mind.

I ſhall now give ſome examples of the operations of aſſociating inſects, who conſtruct habitations by exerting a common and a mutual labour.

The ſkill and dexterity of the *honey-bees*, diſplayed in the conſtruction of their combs or neſts, have at all times called forth the admiration of mankind. They are compoſed of cells regularly applied to each others ſides. Theſe cells are uniform hexagons or ſix-ſided figures. In a bee-hive, every part is arranged with ſuch ſymmetry, and ſo finely finiſhed, that, if limited to the ſame materials, the moſt expert workman would find himſelf unqualified to conſtruct a ſimilar habitation, or rather a ſimilar city.

Moſt Natural Hiſtorians have celebrated bees for their wiſdom, for the perfection and harmony of their republican government, and for their perſevering induſtry and wonderful oeconomy. All theſe ſplendid talents, however, the late ingenious Count de Buffon has endeavoured to perſuade us, are only reſults of pure mechaniſm. But this is not the proper place to enter into a diſcuſſion of this point. It will fall more naturally to be treated of when we come to deſcribe the ſocieties eſtabliſhed among different gregarious animals. We ſhall therefore, at preſent, confine ourſelves chiefly to the mode in which bees conſtruct their habitations.

In the formation of their combs, bees ſeem to reſolve a problem which would not be a little puzzling to ſome geometers, namely, A quantity of wax being given, to make of it equal and ſimilar cells of a determined capacity, but of the largeſt ſize in proportion to the quantity of matter employed, and diſpoſed in ſuch a manner

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as to occupy in the hive the leaſt poſſible ſpace. Every part of this problem is completely executed by the bees. By applying hexagonal cells to each other's ſides, no void ſpaces are left between them; and, though the ſame end might be accompliſhed by other figures, yet they would neceſſarily require a greater quantity of wax. Beſides, hexagonal cells are better fitted to receive the cylindrical bodies of theſe inſects. A comb conſiſts of two ſtrata of cells applied to each other's ends. This arrangement both ſaves room in the hive, and gives a double entry into the cells of which the comb is compoſed. As a farther ſaving of wax, and preventing void ſpaces, the baſes of the cells in one ſtratum of a comb ſerve for baſes to the oppoſite ſtratum. In a word, the more minutely the conſtruction of theſe cells are examined, the more will the admiration of the obſerver be excited. The walls of the cells are ſo extremely thin, that their mouths would be in danger of ſuffering by the frequent entering and iſſuing of the bees. To prevent this diſaſter, they make a kind of ring round the margin of each cell, and this ring is three or four times thicker than the walls.

It is difficult to perceive, even with the aſſiſtance of glaſs-hives, the manner in which bees operate when conſtructing their cells. They are ſo eager to afford mutual aſſiſtance, and, for this purpoſe, ſo many of them crowd together, and are perpetually ſucceeding each other, that their individual operations can ſeldom be diſtinctly obſerved. It has, however, been plainly diſcovered, that their two teeth are the only inſtruments they employ in modelling and poliſhing the wax. With a little patience and attention, we perceive cells juſt begun: We likewiſe remark the quickneſs with which a bee moves its teeth againſt a ſmall portion of the cell. This portion the animal, by repeated ſtrokes on each ſide, ſmooths, renders compact, and reduces to a proper thinneſs of conſiſtence. While ſome of the hive are lengthening their hexagonal tubes, others are laying

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the foundations of new ones. In certain circumſtances, when extremely hurried, they do not complete their new cells, but leave them imperfect till they have begun a number ſufficient for their preſent exigencies. When a bee puts its head a little way into a cell, we eaſily perceive it ſcraping the walls with the points of its teeth, in order to detach ſuch uſeleſs and irregular fragments as may have been left in the work. Of theſe fragments the bee forms a ball about the ſize of a pin-head, comes out of the cell, and carries this wax to another part of the work where it is needed. It no ſooner leaves the cell than it is ſucceeded by another bee, which performs the ſame office, and in this manner the work is ſucceſſively carried on till the cell is completely poliſhed.

The cells of bees are deſigned for different purpoſes. Some of them are employed for the accumulation and preſervation of honey. In others, the female depoſits her eggs, and from theſe eggs worms are hatched, which remain in the cells till their final transformation into flies. The drones or males are larger than the common or working bees; and the queen, or mother of the hive, is much larger than either. A cell deſtined for the lodgement of a male or female worm muſt, therefore, be conſiderably larger than the cells of the ſmaller working bees. The number of cells deſtined for the reception of the working bees far exceeds thoſe in which the males are lodged. The honey-cells are always made deeper and more capacious than the others. When the honey collected is ſo abundant that the veſſels cannot contain it, the bees lengthen, and of courſe deepen the honey-cells.

Their mode of working, and the diſpoſition and diviſion of their labour, when put into an empty hive, do much honour to the ſagacity of bees. They immediately begin to lay the foundations of their combs, which they execute with ſurpriſing quickneſs and alacrity.

crity. Soon after they begin to conftruct one comb, they divide into two or three companies, each of which, in different parts of the hive, is occupied with the fame operations. By this divifion of labour, a greater number of bees have an opportunity of being employed at the fame time, and, confequently, the common work is fooner finifhed. The combs are generally arranged in a direction parallel to each other. An interval or ftreet between the combs is always left, that the bees may have a free paffage, and an eafy communication with the different combs in the hive. Thefe ftreets are juft wide enough to allow two bees to pafs one another. Befide thefe parallel ftreets, to fhorten their journey when working, they leave feveral round crofs paffages, which are always covered.

Hitherto we have chiefly taken notice of the manner in which bees conftruct and polifh their cells, without treating of the materials they employ. We have not marked the difference between the crude matter collected from flowers and the true wax. Every body knows that bees carry into their hives, by means of their hind thighs, great quantities of the farina or duft of flowers. After many experiments made by Reaumur, with a view to difcover whether this duft contained real wax, he was obliged to acknowledge, that he could never find that wax formed any part of its compofition. He at length difcovered, that wax was not a fubftance produced by the mixture of farina with any glutinous fubftance, nor by trituration, or any mechanical operation. By long and attentive obfervation, he found that the bees actually eat the farina which they fo induftrioufly collect; and that this farina, by an animal procefs, is converted into wax. This digeftive procefs, which is neceffary to the formation of wax, is carried on in the fecond ftomach, and perhaps in the inteftines of bees. After knowing the place where this operation is performed, chymifts will probably allow, that it is equally difficult to make real wax with the farina of flowers, as to make chyle with animal or vegetable ſubſtances, a work which is daily executed by our own ſtomach and inteſtines, and by thoſe of other animals. Reaumur likewiſe diſcovered, that all the cells in a hive were not deſtined for the reception of honey, and for depoſiting the eggs of the female, but that ſome of them were employed as receptacles for the farina of flowers, a ſpecies of food that bees find neceſſary for the formation of wax, which is the great baſis and raw material of all their curious operations. When a bee comes to the hive with its thighs filled with farina, it is often met near the entrance by ſome of its companions, who firſt take off the load, and then devour the proviſions ſo kindly brought to them. But, when none of the bees employed in the hive are hungry for this ſpecies of food, the carriers of the farina depoſit their loads in cells prepared for that purpoſe. To theſe cells the bees reſort, when the weather is ſo bad that they cannot venture to go to the fields in queſt of freſh proviſions. The carrying bees, however, commonly enter the hive loaded with farina. They walk along the combs beating and making a noiſe with their wings. By theſe movements they ſeem to announce their arrival to their companions. No ſooner has a loaded bee made theſe movements, than three or four of thoſe within leave their work, come up to it, and firſt take off its load, and then eat the materials it has brought. As a farther evidence that the bees actually eat the farina of flowers, when the ſtomach and inteſtines are laid open, they are often found to be filled with this duſt, the grains of which, when examined by the microſcope, have the exact figure, colour, and conſiſtence of farina, taken from the antherae of particular flowers. After the farina is digeſted, and converted into wax, the bees poſſeſs the power of bringing it from their ſtomachs to their mouths. The inſtrument they employ in furniſhing materials for conſtructing their waxen cells is their tongue. This tongue is ſituated below the two teeth or fangs. When at work, the tongue may be ſeen by the aſſiſtance of a lens and a glaſs-

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hive. It is then in perpetual motion, and its motions are extremely rapid. Its figure continually varies. Sometimes it is more ſharp, at others it is flatter, and ſometimes it is more or leſs concave, and partly covered with a moiſt paſte or wax. By the different movements of its tongue the bee continues to ſupply freſh wax to the two teeth, which are employed in raiſing and faſhioning the walls of its cell, till they have acquired a ſufficient height. As ſoon as the moiſt paſte or wax dries, which it does almoſt inſtantaneouſly, it then aſſumes all the appearances and qualities of common wax. There is a ſtill ſtronger proof that wax is the reſult of an animal proceſs. When bees are removed into a new hive, and cloſely confined from the morning to the evening, if the hive chances to pleaſe them, in the courſe of this day ſeveral waxen cells will be formed, without the poſſibility of a ſingle bee's having had acceſs to the fields. Beſides, the rude materials, or the farina of plants, carried into the hive, are of various colours. The farina of ſome plants employed by the bees is whitiſh; in others it is of a fine yellow colour; in others it is almoſt entirely red; and in others it is green. The combs conſtructed with theſe differently coloured materials are, however, uniformly of the ſame colour. Every comb, eſpecially when it is newly made, is of a pure white colour, which is more or leſs tarniſhed by age, the operation of the air, or by other accidental circumſtances. To bleach wax, therefore, requires only the art of extracting ſuch foreign bodies as may have inſinuated themſelves into its ſubſtance and changed its original colour.

Bees, from the nature of their conſtitution, require a warm habitation. They are likewiſe extremely ſolicitous to prevent inſects of any kind from getting admittance into their hives. To accompliſh both theſe purpoſes, when they take poſſeſſion of a new hive, they carefully examine every part of it, and, if they diſcover any ſmall holes or chinks, they immediately paſte them firmly up with a reſi-

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nous ſubſtance which differs conſiderably from wax. This ſubſtance was not unknown to the ancients. Pliny mentions it under the name of *propolis*, or bee-glue. Bees uſe the propolis for rendering their hives more cloſe and perfect, in preference to wax, becauſe the former is more durable, and more powerfully reſiſts the viciſſitudes of weather than the latter. This glue is not, like wax, procured by an animal proceſs. The bees collect it from different trees, as the poplars, the birches, and the willows. It is a complete production of Nature; and requires no addition or manufacture from the animals by which it is employed. After a bee has procured a quantity ſufficient to fill the cavities in its two hind thighs, it repairs to the hive. Two of its companions inſtantly draw out the propolis, and apply it to fill up ſuch chinks, holes, or other deficiencies, as they find in their habitation. But this is not the only uſe to which bees apply the propolis. They are extremely ſolicitous to remove ſuch inſects or foreign bodies as happen to get admiſſion into the hive. When ſo light as not to exceed their powers, they firſt kill the inſect with their ſtings, and then drag it out with their teeth. But it ſometimes happens that an ill-fated ſnail creeps into the hive. It is no ſooner perceived than it is attacked on all ſides and ſtung to death. But how are the bees to carry out a burden of ſuch weight? This labour they know would be in vain. They are perhaps apprehenſive that a body ſo large would diffuſe, in the courſe of its putrefaction, a diſagreeable or noxious odour through the hive. To prevent ſuch hurtful conſequences, immediately after the animal's death, they embalm it, by covering every part of its body with propolis, through which no effluvia can eſcape. When a ſnail with a ſhell gets entrance, to diſpoſe of it gives much leſs trouble and expence to the bees. As ſoon as this kind of ſnail receives the firſt wound from a ſting, it naturally retires within its ſhell. In this caſe, the bees, inſtead of paſting it all over with propolis, content themſelves with

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gluing all round the margin of the ſhell, which is ſufficient to render the animal forever immoveably fixed.

But propolis, and the materials for making wax, are not the only ſubſtances theſe induſtrious animals have to collect. As formerly remarked, beſide the whole winter, there are many days in ſummer in which the bees are prevented by the weather from going abroad in queſt of proviſions. They are, therefore, under the neceſſity of collecting, and amaſſing in cells deſtined for that purpoſe, large quantities of honey. This ſweet and balſamic liquor they extract, by means of their proboſcis or trunk, from the nectariferous glands of flowers. The trunk of a bee is a kind of rough cartilaginous tongue. After collecting a few ſmall drops of honey, the animal with its proboſcis conveys them to its mouth and ſwallows them. From the oeſophagus or gullet, it paſſes into the firſt ſtomach, which is more or leſs ſwelled in proportion to the quantity of honey it contains. When empty, it has the appearance of a fine white thread: But, when filled with honey, it aſſumes the figure of an oblong bladder, the membrane of which is ſo thin and tranſparent, that it allows the colour of the liquor it contains to be diſtinctly ſeen. This bladder is well known to children who live in the country. They cruelly amuſe themſelves with catching bees, and tearing them aſunder, in order to ſuck the honey. A ſingle flower furniſhes but a ſmall quantity of honey. The bees are, therefore, obliged to fly from one flower to another till they fill their firſt ſtomachs. When they have accompliſhed this purpoſe, they return directly to the hive, and diſgorge in a cell the whole honey they have collected. It not unfrequently happens, however, that, when on its way to the hive, it is accoſted by a hungry companion. How the one can communicate its neceſſity to the other, it is perhaps impoſſible to diſcover. But the fact is certain, that, when two bees meet in this ſituation, they mutually ſtop, and the one whoſe ſtomach is full of honey extends

tends its trunk, opens its mouth, which lies a little beyond the teeth, and, like ruminating animals, forces up the honey into that cavity. The hungry bee knows how to take advantage of this hoſpitable invitation. With the point of its trunk it ſucks the honey from the other's mouth. When not ſtopped on the road, the bee proceeds to the hive, and in the ſame manner offers its honey to thoſe who are at work, as if it meant to prevent the neceſſity of quitting their labour in order to go in queſt of food. In bad weather, the bees feed upon the honey laid up in open cells; but they never touch theſe reſervoirs when their companions are enabled to ſupply them with freſh honey from the fields. But the mouths of thoſe cells which are deſtined for preſerving honey during winter, they always cover with a lid or thin plate of wax.

Though not ſtrictly connected with the preſent ſubject, we cannot refrain from giving ſome account of the ingenious Mr Debraw's diſcoveries concerning the ſex of bees, and the manner in which their ſpecies is multiplied *. It was almoſt univerſally believed, both by ancients and moderns, that bees, like other animals, propagated by an actual intercourſe of the male and female, though it never could be perceived by the moſt attentive obſervers. Pliny remarks, that *apium coitus viſus eſt nunquam;* and even the indefatigable Reaumur, notwithſtanding the many minute reſearches and experiments he made concerning every part of the oeconomy of bees, and though he repreſents the mother, or queen-bee, as a perfect Meſſalina, could never detect an actual intercourſe. From this ſingular circumſtance, Maraldi, in his obſervations upon bees †, conjectured that the eggs of bees, like thoſe of fiſhes, were impregnated after they were depoſited in the cells by the mother. He was farther

* See Philoſophical Tranſactions, ann. 1777, Part I. page 15.

† Hiſt. de l'Acad. de Scien. ann. 1712.

ther confirmed in this opinion, by uniformly obferving that a whitifh liquid fubftance furrounded each egg which turned out to be fertile; but that thofe eggs round which no fuch fubftance was to be found were always barren. The working bees, or thofe which collect from flowers the materials of wax, have generally been confidered as belonging to neither fex. But Mr Schirach, a German Naturalift, in his *Hiftory of the Queen of the Bees*, maintains, that all the common bees are females in a difguifed or barren ftate; that the organs which diftinguifh the fex, and particularly the ovaria, are either obliterated, or, on account of their minutenefs, have not hitherto been difcovered; that, in the early period of its exiftence, every one of thefe bees is capable of becoming a queen-bee, if the community choofe to nurfe it in a certain manner, and to raife it to that diftinguifhed rank; and that the queen-bee lays only two kinds of eggs, namely, thofe that are to produce drones or males, and thofe from which the working bees are to proceed.

The conjecture of Maraldi concerning the impregnation of the eggs after they are depofited in the cells, as well as the obfervations of Mr Schirach concerning the fex of the working bees, have been completely verified by the experiments of Mr Debraw. Both Maraldi and Reaumur had long ago difcovered, that, in every hive, befide the large drones, there are males or drones as fmall as the working bees. By means of glafs-hives, Mr Debraw obferved, that the queen-bee begins to depofit her eggs in the cells on the fourth or fifth day after the bees begin to work. On the firft or fecond day after the eggs are placed in the cells, he perceived feveral bees finking the pofterior parts of their bodies into each cell, where they continued but a fhort time. After they had retired, he faw plainly with the naked eye a fmall quantity of whitifh liquor left in the bottom of each cell that contained an egg. Next day he found that this liquor was abforbed into the egg, which, on the fourth day, is

 hatched.

hatched. When the worms eſcape from the eggs, they are fed for eight or ten days with honey by the working bees. After that period they ſhut up the mouths of the cells, where the worms continue incloſed for ten days more, during which time they undergo their different transformations.

'I immerſed,' ſays Mr Debraw, 'all the bees in water; and, 'when they appeared to be in a ſenſeleſs ſtate, I gently preſſed every 'one of them between my fingers, in order to diſtinguiſh thoſe 'armed with ſtings from thoſe that had none, which laſt I might 'ſuſpect to be males. Of theſe I found ſixty-ſeven, exactly of the 'ſize of common bees, yielding a little whitiſh liquor on being preſ'ſed between the fingers. I killed every one, and replaced the 'ſwarm in a glaſs-hive, where they immediately applied again to 'the work of making cells; and, on the fourth or fifth day, very 'early in the morning, I had the pleaſure to ſee the queen-bee de'poſiting her eggs in thoſe cells, which ſhe did by placing the po'ſterior part of her body in each of them. I continued to watch 'moſt part of the enſuing days, but could diſcover nothing of what 'I had ſeen before. The eggs, after the fourth day, inſtead of 'changing in the manner of caterpillars, were found in the ſame 'ſtate they were in the firſt day.' The next day about noon, the whole ſwarm forſook the hive, probably becauſe the animals perceived, that, without the aſſiſtance of males, they were unqualified to multiply their ſpecies. To ſhow the neceſſity of the eggs being fecundated by the male influence, Mr Debraw relates an experiment ſtill more deciſive.

'I took,' ſays he, 'the brood-comb, which, as I obſerved before, 'had not been impregnated; I divided it into two parts; one I 'placed under a glaſs-bell, No. 1. with honey-comb for the bees 'food; I took care to leave a queen, but no drones, among the com-

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'mon bees I confined in it. The other piece of brood-comb I placed 'under another glafs-bell, No. 2. with a few drones, a queen, and 'a number of common bees proportioned to the fize of the glafs. 'The refult was, that, in the glafs No. 1. no impregnation happen'ed; the eggs remained in the fame ftate they were in when put in'to the glafs; and, upon giving the bees their liberty on the feventh 'day, they all flew away, as was found to be the cafe in the former 'experiment: Whereas, in the glafs No. 2. I faw, the very day af'ter the bees had been put under it, the impregnation of the eggs 'by the drones in every cell containing eggs; the bees did not leave 'their hive on receiving their liberty; and, in the courfe of twenty 'days, every egg underwent all the above mentioned neceffary 'changes, and formed a pretty numerous young colony, in which I 'was not a little ftartled to find *two* queens.'

The appearance of a new queen in a hive where there was no large or royal cell, made Mr Debraw conjecture that the bees are capable, by fome particular means, of transforming a common fubject into a queen. To afcertain the truth of this conjecture, he provided himfelf with four glafs-hives, into each of which he put a piece of brood-comb taken from an old hive. Thefe pieces of brood-comb contained eggs, worms, and nymphs. In each hive he confined a fufficient number of common bees, and fome drones or males, but took care that there fhould be no queen.

'The bees,' Mr Debraw remarks, 'finding themfelves without a 'queen, made a ftrange buzzing noife, which lafted near two days, 'at the end of which they fettled, and betook themfelves to work. 'On the fourth day, I perceived in each hive the beginning of a 'royal cell, *a certain indication that one of the inclofed worms would* '*foon be converted into a queen.* The conftruction of the royal cell 'being nearly accomplifhed, I ventured to leave an opening for the 'bees to get out, and found that they returned as regularly as they 'do in common hives, and ſhewed no inclination to leave their habitation. But, to be brief, at the end of twenty days, I obſerved 'four young queens among the new progeny.'

To theſe experiments of Mr Debraw, it was objected, that the queen-bee, beſide the eggs which ſhe depoſits in the royal cells, might likewiſe have laid royal or female eggs in the common cells; and that the pieces of brood-comb, ſo ſuccefsfully employed in his experiments for the production of a queen, had always happened to contain one of theſe royal eggs, or rather one of the worms proceeding from them. But this objection was afterwards removed by many other accurate experiments, the reſults of which were uniformly the ſame; and the objectors to Mr Debraw's diſcovery candidly admit, that, when the community ſtands in need of a queen, the working-bees poſſeſs the power of raiſing a common ſubject to the throne; and that every worm of the hive is capable, under a certain courſe of management, of becoming the mother of a numerous progeny. This metamorphoſis ſeems to be chiefly accompliſhed by a peculiar nouriſhment carefully adminiſtered to the worm by the working-bees, by which, and perhaps by other unknown means, the female organs, the germs of which previouſly exiſted in the embryo, are expanded, and all thoſe differences in form and ſize, that ſo remarkably diſtinguiſh the queen from the working-bees, are produced.

It is always a fortunate circumſtance when diſcoveries, which at firſt ſeem calculated ſolely to gratify curioſity, are capable of being turned to the advantage of ſociety. Mr Debraw, accordingly, has not failed to point out the advantages that may be derived from his reſearches into the oeconomy and nature of bees. By his diſcovery, we are taught an eaſy mode of multiplying, without end, ſwarms, or new colonies, of theſe uſeful inſects. Beſide the great increaſe of of honey, if this difcovery were fufficiently attended to, confiderable fums annually expended in importing wax into this kingdom from the Continent might be faved. The practice of this new art, Mr Schirach informs us, has already extended itfelf through Upper Lufatia, the Palatinate, Bohemia, Bavaria, Silefia, and Poland. In fome of thefe countries, it has excited the attention, and acquired the patronage, of government. The Emprefs of Ruffia, who never lofes fight of a fingle article by which the induftry, and, of courfe, the happinefs of her fubjects can be augmented, has fent a proper perfon to Klein Bautzen to be inftructed in the general principles, and to learn all the minutiae of this new and important art.

Wafps, like the bees, affociate in great numbers, and conftruct, with much dexterity and fkill, a common habitation. There are many fpecies of wafps, fome of which unite into focieties, and others fpend their lives in perfect folitude. But, in this place, we fhall confine our attention to the operations of the common affociating wafp, an infect fo well known, even to children, that it requires no defcription. Though bees, as well as wafps, are armed with a fting, yet the former may be regarded as a placid and harmlefs race. Bees are continually occupied with their own labours. Their chief care is to defend themfelves; and they never take nourifhment at the expence of any other animal. Wafps, on the contrary, are ferocious animals, who live entirely on rapine and deftruction. They kill and devour every infect that is inferior to them in ftrength. But, though warlike and rapacious in their general manners, they are polifhed and peaceable among themfelves. To their young they difcover the greateft tendernefs and affection. For their protection and conveniency no labour is fpared; and the habitations they conftruct do honour to their patience, addrefs, and fagacity. Their architecture, like that of the honey-bee, is fingular, and worthy of admiration; but the materials employed furnifh neither honey nor wax. Impelled by an inſtinctive love of poſterity, they, with great labour, ſkill, and aſſiduity, conſtruct combs, which are likewiſe compoſed of hexagonal or ſix-ſided cells. Though theſe cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them till their transformation into waſps.

In general, the cells of the waſps are formed of a kind of paper, which, with great dexterity, is fabricated by the animals themſelves. The number of combs and cells in a waſp's neſt is always proportioned to the number of individuals aſſociated. Different ſpecies chooſe different ſituations for building their neſts. Some expoſe their habitations to all the injuries of the air; others prefer the trunks of decayed trees; and others, as the common kind, of which we are principally treating, conceal their neſts under ground. The hole which leads to a waſp's neſt is about an inch in diameter. This hole is a kind of gallery mined by the waſps, is ſeldom in a ſtraight line, and varies in length from half a foot to two feet, according to the diſtance of the neſt from the ſurface of the ground. When expoſed to view, the whole neſt appears to be of a roundiſh form, and ſometimes about twelve or fourteen inches in diameter. It is ſtrongly fortified all round with walls or layers of paper, the ſurface of which is rough and irregular. In theſe walls, or rather in this external covering, two holes are left for paſſages to the combs. The waſps uniformly enter the neſt by one hole, and go out by the other, which prevents any confuſion or interruption to their common labours.

We are now arrived at the gates of this ſubterraneous city, which, though ſmall, is extremely populous. Upon removing the external covering, we perceive that the whole interior part conſiſts of ſeveral ſtoreys or floors of combs, which are parallel to each other, and

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nearly in a horizontal pofition. Every ftorey is compofed of a numerous affemblage of hexagonal cells, very regularly conftructed with a matter refembling afh-coloured paper. Thefe cells contain neither wax nor honey, but are folely deftined for containing the eggs, the worms which are hatched from them, the nymphs, and the young wafps till they are able to fly. Wafps nefts are not always compofed of an equal number of combs. They fometimes confift of fifteen, and fometimes of eleven only. The combs are of various diameters. The firft, or uppermoft, is often only two inches in diameter, while thofe of the middle fometimes exceed a foot. The loweft are alfo much fmaller than the middle ones. All thefe combs, like fo many floors or ftoreys ranged parallelly above each other, afford lodging to prodigious numbers of inhabitants. Reaumur computed, from the number of cells in a given portion of comb, that, in a medium fized neft, there were at leaft 10,000 cells. This calculation gives an idea of the aftonifhing prolific powers of thefe infects, and of the vaft numbers of individuals produced in a fingle feafon from one neft; for every cell ferves as a lodging to no lefs than three generations. Hence a moderately fized neft gives birth annually to 30,000 young wafps.

The different ftoreys of combs are always about half an inch high, which leaves free paffages to the wafps from one part of the neft to another. Thefe intervals are fo fpacious, that, in proportion to the bulk of the animals, they may be compared to great halls, or broad ftreets. Each of the larger combs is fupported by about fifty pillars, which, at the fame time, give folidity to the fabric, and greatly ornament the whole neft. The leffer combs are fupported by the fame ingenious contrivance. Thefe pillars are coarfe, and of a roundifh form. Their bafes and capitals, however, are much larger in diameter than towards the middle. By the one end they are attached to the fuperior comb, and by the other to the inferior. Thus

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between two combs there is always a fpecies of ruftic colonade. The wafps begin at the top and build downward. The uppermoft and fmalleft comb is firft conftructed. It is attached to the fuperior part of the external covering. The fecond comb is fixed to the bottom of the firft; and in this manner the animals proceed till the whole operation is completed. The connecting pillars are compofed of the fame kind of paper as the reft of the neft. To allow the wafps entries into the void fpaces, roads are left between the combs and the external envelope or covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the wafps build, and how they employ themfelves in their abodes. But, as all thefe myfteries are performed under the earth, it required much induftry and attention to difcover them. By the ingenuity and perfeverance of M. de Reaumur, however, we are enabled to explain fome parts of their internal oeconomy and manners. This indefatigable naturalift contrived to make wafps, like the honey-bees, lodge and work in glafs-hives. In this operation he was greatly affifted by the ardent affection which thefe animals have to their offspring; for he found, that, though the neft was cut in different directions, and though it was expofed to the light, the wafps never deferted it, nor relaxed in their attention to their young. When placed in a glafs-hive, they are perfectly peaceable, and never attack the obferver, if he calmly contemplates their operations; for, naturally, they do not fting, unlefs they are irritated.

Immediately after a wafp's neft has been tranfported from its natural fituation, and covered with a glafs-hive, the firft operation of the infects is to repair the injuries it has fuffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them occupy

 themfelves

themſelves fixing the neſt to the top and ſides of the hive by pillars of paper ſimilar to thoſe which ſupport the different ſtories or ſtrata of combs; others repair the breaches it has ſuſtained; and others fortify it by augmenting conſiderably the thickneſs of its external cover. This external envelope is an operation peculiar to waſps. Its conſtruction requires great labour; for it frequently exceeds an inch and a half in thickneſs, and is compoſed of a number of ſtrata or layers as thin as paper, between each of which there is a void ſpace. This cover is a kind of box for incloſing the combs, and defending them from the rain which occaſionally penetrates the earth. For this purpoſe it is admirably adapted. If it were one ſolid maſs, the contact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave conſiderable vacuities between each vaulted layer, which are generally fifteen or ſixteen in number. By this ingenious piece of architecture, one or two layers may be moiſtened with water, while the others are not in the leaſt affected.

The materials employed by waſps in the conſtruction of their neſts are very different from thoſe made uſe of by the honey-bee. Inſtead of collecting the farina of flowers, and digeſting it into wax, the waſps gnaw with their two fangs, which are ſtrong and ſerrated, ſmall fibres of wood from the ſaſhes of windows, the poſts of eſpaliers, garden doors, &c. but never attempt growing or green timber. Theſe fibres, which, though very ſlender, are often a line, or a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, tranſport them to their neſt, and, by means of a glutinous ſubſtance furniſhed from their own bodies, form them into a moiſt and ductile paſte. Of this ſubſtance, or *papier maché*, they conſtruct the external cover, the partitions of the neſt, the hexagonal cells, and the ſolid columns which ſupport the ſeveral layers or ſtories of combs.

The conſtructing of the neſt occupies a comparatively ſmall number of labourers. The others are differently employed. Here it is neceſſary to remark, that the republics of waſps, like thoſe of the honey-bees, conſiſt of three kinds of flies, males, females, and neuters. Like the bees, alſo, the number of neuters far ſurpaſſes thoſe of both males and females. The greateſt quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their different operations which the females, at certain times, do not execute. Neither do the males, though their induſtry is not comparable to that of the neuters, remain entirely idle. They often occupy themſelves in the interior part of the neſt. The greateſt part of the labour, however, is performed by the neuters. They build the neſt, feed the males, the females, and even the young. But, while the neuters are employed in theſe different operations, the others are abroad in hunting parties. Some attack with intrepidity live inſects, which they ſometimes carry entire to the neſt; but they generally tranſport the abdomen or belly only. Others pillage butchers ſtalls, from which they often arrive with a piece of meat larger than the half of their own bodies. Others reſort to gardens, and ſuck the juices of fruits. When they return to the neſt, they diſtribute a part of their plunder to the females, to the males, and even to ſuch neuters as have been uſefully occupied at home. As ſoon as a neuter enters the neſt, it is ſurrounded by ſeveral waſps, to each of whom it freely gives a portion of the food it has brought. Thoſe who have not been hunting for prey, but have been ſucking the juices of fruits, though they ſeem to return empty, fail not to regale their companions; for, after their arrival, they ſtation themſelves upon the upper part of the neſt, and diſcharge from their mouths two or three drops of a clear liquid, which are immediately ſwallowed by the domeſtics.

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The neuter wafps, though the moft laborious, are the fmalleft; but they are extremely active and vivacious. The females are much larger, heavier, and flower in their movements. The males are of an intermediate fize between that of the females and neuters. From thefe differences in fize, it is eafy to diftinguifh the different kinds of thofe wafps which build their nefts below the ground. In the hive of the honey-bee, the number of females is always extremely fmall; but, in a wafp's neft, there are often more than three hundred females. During the months of June, July, and Auguft, they remain conftantly in the neft, and are never feen abroad except in the beginning of fpring, and in the months of September and October. During the fummer, they are totally occupied in laying their eggs and feeding their young. In this laft operation, they are affifted by the other wafps; for the females alone, though numerous, would be infufficient for the laborious tafk. A wafp's neft, when completed, fometimes confifts of fixteen thoufand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, tranfparent, of an oblong figure, and differ in fize, according to the kind of wafps which are to proceed from them. Some of them are no larger than the head of a fmall pin. They are fo firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are depofited in the cells, the worms are hatched, and are confiderably larger than the eggs which gave birth to them. Thefe worms demand the principal cares of the wafps who continue always in the neft. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is aftonifhing to fee with what induftry and rapidity a female runs along the cells of a comb, and diftributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with folid food, fuch as the bellies of infects, or with a liquid fubftance difgorged by the mother. When a worm is fo large as to occupy its whole cell, it is then ready to be metamorphofed into a nymph. It then refufes all nourifhment, and ceafes to have any connection with the wafps in the neft. It fhuts up the mouth of its cell with a fine filken cover, in the fame manner as the filk-worm and other caterpillars fpin their cods. This operation is completed in three or four hours, and the animal remains in the nymph ftate nine or ten days, when, with its teeth, it deftroys the external cover of the cell, and comes forth in the form of a winged infect, which is either male, female, or neuter, according to the nature of the egg from which it was hatched. In a fhort time, the wafps newly transformed receive the food brought into the neft by the foragers in the fields. What is ftill more curious, in the courfe of the firft day after their transformation, the young wafps have been obferved going to the fields, bringing in provifions, and diftributing them to the worms in the cells. A cell is no fooner abandoned by a young wafp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every refpect, proper for the reception of another egg.

As formerly mentioned, wafps of different fexes differ greatly in fize. The animals know how to conftruct cells proportioned to the dimenfions of the fly that is to proceed from the egg which the female depofits in them. The neuters are fix times fmaller than the females, and their cells are built nearly in the fame proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with thofe of the males or females. A comb is entirely occupied with fmall cells fitted for the reception of neuter worms. But male and female cells are often found in the fame comb. The males and females are of equal length, and, of courfe, require cells of an equal deepnefs. But the cells of the males are narrower than thofe of the females, becaufe the bodies of the former are never fo thick as thofe of the latter.

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This wonderful aſſemblage of combs, of the pillars which ſupport them, and of the external envelope, is an edifice which requires ſeveral months labour, and ſerves the animals one year only. This habitation, ſo populous in ſummer, is almoſt deſerted in winter, and abandoned entirely in ſpring; for, in this laſt ſeaſon, not a ſingle waſp is to be found in a neſt of the preceding year. It is worthy of remark, that the firſt combs of a neſt are always accommodated for the reception of the neuter or working waſps. The city, of which the foundation has juſt been laid, requires a number of workmen. The neuter or working waſps are accordingly firſt produced. A cell is no ſooner half completed than an egg of a neuter is depoſited in it by the female. Of fourteen or fifteen combs incloſed in a common cover, the four laſt only are deſtined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every waſp's neſt is peopled with ſeveral thouſand neuters or workers. But the neuters, who are firſt produced, are likewiſe the firſt that periſh; for not one of them ſurvives the termination even of a mild winter. It was remarked by the ancient naturaliſts, that ſome waſps lived one year only, and others two. To the former Ariſtotle gives the appellation of *operarii*, which are our workers or neuters, and to the latter *matrices*, which are our females.

The female waſps are ſtronger, and ſupport the rigours of winter better than the males or neuters. Before the end of winter, however, ſeveral hundred females die, and not above ten or a dozen in each neſt ſurvive that ſeaſon. Theſe few females are deſtined for the continuation of the ſpecies. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive in order to eſtabliſh a new one, ſhe is always accompanied with ſeveral thouſand induſtrious labourers, ready to perform every neceſſary operation. But the female waſp has not the aid of a ſingle labour-

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er; for all the neuters are dead before the beginning of the ſpring. The female alone lays the foundation of a new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of theſe neuter worms are transformed into flies, they immediately aſſiſt their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female waſp, which in ſpring was perfectly ſolitary, without any proper habitation, and had every operation to perform, has, in autumn, ſeveral thouſands of her offspring at her devotion, and is furniſhed with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male waſps, it is uncertain whether any of them ſurvive the winter. But, though not ſo indolent as the males of the honey-bee, they can be of little aſſiſtance to the female; for they never engage in any work of importance, ſuch as conſtructing cells, or fortifying the external cover of the neſt. They are never brought forth till towards the end of Auguſt; and their ſole occupation ſeems to be that of keeping the neſt clean: They carry out every kind of filth, and the carcaſſes of ſuch of their companions as happen to die. In performing this operation, two of them often join, and, as mentioned in another place, when the load is too heavy, they cut off the head, and tranſport the dead animal at two times.

In the beginning of ſpring, when the female waſp has built her ſubterraneous habitation, which is ſoon to be peopled with thouſands of flies, ſhe has no occaſion for the males; becauſe, in the month of September or October, ſhe had been previouſly impregnated. The males and females are produced at the ſame time, and they are nearly equal in number. Like the male honey-bees, the male waſps are deſtitute deftitute of ftings, but the females and neuters have ftings, the poifonous liquor of which, when introduced into any part of the human body, excites inflammation, and creates a confiderable degree of pain.

The habitations and the oeconomy of the common *ant* are exceedingly curious. But, as they are fo well known, and fo obvious to infpection and examination, we fhall not detain the reader with a defcription of them. To fupply this defect, we fhall give fome account of the truly wonderful operations of the *termites*, which are generally called *white-ants* *, though they belong to a different genus of infects. Thefe animals infeft Guinea, and all the tropical regions, where, for their depredations of property, they are greatly dreaded by the inhabitants; from which circumftance they have received the name of *Fatalis* or *Deftructor*.

The following abridged account of the *termites*, and of the wonderful habitations they build, is felected from an excellent defcription of them in a Letter from Mr Henry Smeathman, of Clement's Inn, to Sir Jofeph Banks, which was publifhed in the Philofophical Tranfactions †. Though the nefts, or rather hills, conftructed by the termites, are mentioned by many travellers, their defcriptions and obfervations are by no means fo accurate as thofe of the ingenious Mr Smeathman. Of thefe infects there are feveral fpecies; but they all refemble each other in form, and in their manner of living. They differ, however, as much as birds, in the ftile of their architecture, and in the felection of the materials of which their nefts

* In the windward parts of Africa, they are denominated *bugga, buggs;* in the Weft Indies, *wood-lice, wood-ants*, or *white-ants*. They are likewife called *piercers, eaters*, or *cutters*, becaufe they cut almoft every thing in pieces.

† Vol. 71. part 1. page 139.

nefts are compofed. Some build on the furface, or partly above and partly below the ground, and others on the trunks or branches of lofty trees.

Before defcribing the nefts or hills, it is neceffary to give fome idea of the animals themfelves, and of their general oeconomy and manners. We fhall confine ourfelves to that fpecies called *termites bellicofi*, or *fighters*, becaufe they are largeft, and beft known on the coaft of Africa.

The republic of the *termines bellicofi*, like the other fpecies of this genus, confifts of three ranks, or orders of infects: 1. The working infects, which Mr Smeathman diftinguifhes by the name of *labourers*; 2. The fighters, or *foldiers*, which perform no kind of labour; and, 3. The winged, or *perfect infects*, which are male and female, and capable of multiplying the fpecies. Thefe laft Mr Smeathman calls the *nobility* or *gentry*; becaufe they neither labour nor fight. The nobility alone are capable of being raifed to the rank of kings and queens. A few weeks after their elevation to this ftate, they emigrate, in order to eftablifh new empires.

In a neft or hill, the labourers, or working infects, are always moft numerous: There are at leaft one hundred labourers to one of the fighting infects or foldiers. When in this ftate, they are about a fourth of an inch in length, which is rather fmaller than fome of our ants. From their figure, and fondnefs for wood, they are very generally known by the name of *wood-lice*.

The fecond order, or foldiers, differ in figure from that of the labourers. The former have been fuppofed to be neuters, and the latter males. But, in fact, they are the fame infects. They have only undergone a change of form, and made a nearer approach to the

the perfect ftate. They are now much larger, being half an inch in length, and equal in fize to fifteen of the labourers. The form of the head is likewife greatly changed. In the labourer ftate, the mouth is evidently formed for gnawing or holding bodies: But, in the foldier ftate, the jaws being fhaped like two fharp awls a little jagged, are deftined folely for piercing or wounding. For thefe purpofes they are very well calculated; for they are as hard as a crab's claw, and placed in a ftrong horny head, which is of a nut-brown colour, and larger than the whole body.

The figure of the third order, or that of the infect in its perfect ftate, is ftill more changed. The head, the thorax, and the abdomen, differ almoft entirely from the fame parts in the labourers and foldiers. Befide, the animals are now furnifhed with four large, brownifh, tranfparent wings, by which they are enabled, at the proper feafon, to emigrate and to eftablifh new fettlements. In the winged or perfect ftate, they have likewife acquired the organs of generation, and are greatly altered in their fize as well as in their figure. Their bodies now meafure between fix and feven tenths of an inch, their wings, from tip to tip, above two inches and a half, and their bulk is equal to that of thirty labourers, or two foldiers. Inftead of active, induftrious, and rapacious little animals, when they arrive at their perfect ftate, they become innocent, helplefs, and daftardly. Their numbers are great; but their enemies are ftill more numerous. They are devoured by birds, by every fpecies of ants, by carnivorous reptiles, and even by the inhabitants of many parts of Africa. This laft fact is attefted by Pifo, Margraave, De Laet, Konig, Moor, Sparman, and by many other travellers, as well as by Smeathman. After fuch devaftation, it is furprifing that a fingle pair fhould efcape fo many dangers. 'Some, however,' fays Mr Smeathman, 'are fo fortunate; and being found by fome of the 'labouring infects, that are continually running about the furface of

‘ the ground under their covered galleries, are *elected Kings* and ‘ *Queens* of new ftates; all thofe who are not fo elected and pre- ‘ ferved certainly perifh. The manner in which thefe labourers ‘ protect the happy pair from their innumerable enemies, not only ‘ on the day of the maffacre of almoft all their race, but for a long ‘ time after, will, I hope, juftify me in the ufe of the term *election*. ‘ The little induftrious creatures immediately inclofe them in a fmall ‘ chamber of clay fuitable to their fize, into which, at firft, they ‘ leave but one fmall entrance, large enough for themfelves and the ‘ foldiers to go in and out, but much too little for either of the roy- ‘ al pair to make ufe of; and, when neceffity obliges them to make ‘ more entrances, they are never larger; fo that, of courfe, the *vo-* ‘ *luntary fubjects* charge themfelves with the tafk of providing for ‘ the offspring of their fovereigns, as well as to work and to fight ‘ for them, until they have raifed a progeny capable at leaft of di- ‘ viding the tafk with them.

‘ It is not till this, probably, that they confummate their mar- ‘ riage, as I never faw a pair of them joined. The bufinefs of pro- ‘ pagation, however, foon commences; and the labourers having ‘ conftructed a fmall wooden nurfery, carry the eggs and lodge ‘ them there as faft as they can obtain them from the *queen*.

‘ About this time a moft extraordinary change begins to take ‘ place in the *queen*, to which I know nothing fimilar, except in the ‘ *pulex penetrans* of Linnaeus, the *jigger* of the Weft Indies, and in ‘ the different fpecies of *coccus*, *cochineal*. The abdomen of this fe- ‘ male begins gradually to extend and enlarge to fuch an enormous ‘ fize, that an *old queen* will have it increafed fo as to be *fifteen hun-* ‘ *dred* or *two thoufand times* the bulk of the reft of her body, and ‘ *twenty* or *thirty thoufand times* the bulk of a labourer, as I have ‘ found by carefully weighing and computing the different ftates.

‘ The

'The ſkin between the ſegments of the abdomen extends in every 'direction; and at laſt the ſegments are removed to half an inch 'diſtance from each other, though, at firſt, the length of the whole 'abdomen is not half an inch. I conjecture the animal is upwards 'of two years old when the abdomen is increaſed to three inches in 'length: I have ſometimes found them of near twice that ſize. The 'abdomen is now of an irregular oblong ſhape, being contracted by 'the muſcles of every ſegment, and is become one vaſt matrix full 'of eggs, which make long circumvolutions through an innumerable 'quantity of very minute veſſels that circulate round the inſide in a 'ſerpentine manner, which would exerciſe the ingenuity of a ſkill-'ful anatomiſt to diſſect and develope. This ſingular matrix is not 'more remarkable for its amazing extenſion and ſize than for its 'periſtaltic motion, which reſembles the undulating of waves, and 'continues inceſſantly without any apparent effort of the animal; 'ſo that one part or other, alternately, is riſing and ſinking in per-'petual ſucceſſion, and the matrix ſeems never at reſt, but is always 'protruding eggs to the amount (as I have frequently counted in 'old queens) of ſixty in a minute, or eighty thouſand and upward 'in one day of twenty-four hours.

'These eggs are inſtantly taken from her body by her attendants, '(of whom there always are, in the royal chamber and the galleries 'adjacent, a ſufficient number in waiting), and carried to the nurſe-'ries, which, in a great neſt, may ſome of them be four or five feet 'diſtant in a ſtraight line, and, conſequently, much farther by their 'winding galleries. Here, after they are hatched, the young are 'attended and provided with every thing neceſſary until they are 'able to ſhift for themſelves, and take their ſhare of the labours of 'the community.'

We ſhall now endeavour to give ſome idea of the almoſt incredible architecture and oeconomy of theſe wonderful inſects.

The neſts of the *termites bellicoſi*, or wood-lice, are called *hills* by the natives of Africa, New Holland, and other hot climates. This appellation is highly proper; for they are often elevated ten or twelve feet above the ſurface of the earth, and are nearly of a conical figure. Theſe hills, inſtead of being rare phenomena, are ſo frequent in many places near Senegal, that, as deſcribed with great propriety by Monſ. Adanſon, their number, magnitude, and cloſeneſs of ſituation, make them appear like villages of the Negroes. 'But, of all the extraordinary things I obſerved,' ſays Monſ. Adanſon, 'nothing ſtruck me more than certain eminences, which, by 'their height and regularity, made me take them, at a diſtance, for 'an aſſemblage of Negroe huts, or a conſiderable village, and yet 'they were only the neſts of certain inſects. Theſe neſts are round 'pyramids, from eight to ten feet high, upon nearly the ſame baſe, 'with a ſmooth ſurface of rich clay, exceſſively hard and well built *.' Jobſon, in his hiſtory of Gambia, tells us, that 'the ant-hills are 'remarkable caſt up in thoſe parts by piſmires, ſome of them twen-'ty foot in height, of compaſſe to contayne a dozen of men, with 'the heat of the ſun baked into that hardneſſe, that we uſed to hide 'ourſelves in the ragged toppes of them, when we took up ſtands 'to ſhoot at deere or wild beaſts †.' Mr Boſman remarks, in his deſcription of Guinea, that 'the ants make neſts of the earth about 'twice the height of a man ‡.'

Each

* Adanſon's Voyage to Senegal, 8vo, pag. 153.—337. Voyage de Senegal, 4to, pag. 83.—99.

† Purchas's Pilgrams, vol. 2. pag. 1570.

‡ Page 276.—493.

Each of thefe hills is compofed of an exterior and an interior part. The exterior cover is a large clay-fhell, which is fhaped like a dome. Its ftrength and magnitude are fufficient to inclofe and protect the interior building from the injuries of the weather, and to defend its numerous inhabitants from the attacks of natural or accidental enemies. The external dome or cover is, therefore, always much ftronger than the internal building, which is the habitation of the infects, and is divided with wonderful artifice and regularity into a vaft number of apartments for the refidence and accommodation of the king and queen, for the nurfing of their progeny, and for magazines, which are always well ftored with provifions.

Thefe hills make their firft appearance in the form of conical turrets about a foot high. In a fhort time, the infects erect, at a little diftance, other turrets, and go on increafing their number and widening their bafes, till their underworks are covered with thefe turrets, which the animals always raife higheft in the middle of the hill, and, by filling up the intervals between each turret, collect them, at laft, into one great dome.

'The *royal chamber*,' Mr Smeathman remarks, 'which is occu-
'pied by the king and queen, appears to be, in the opinion of this
'little people, of the moft confequence, and is always fituated as
'near the centre of the interior building as poffible, and generally
'about the height of the common furface of the ground. It is al-
'ways nearly in the fhape of half an egg, or an obtufe oval, within,
'and may be fuppofed to reprefent a long oven. In the infant ftate
'of the colony, it is not above an inch, or thereabout, in length;
'but in time will be increafed to fix or eight inches, or more, in the
'clear, being always in proportion to the fize of the queen, who,
'increafing in bulk as in age, at length requires a chamber of fuch
'dimenfions.'

The

The entrances into the royal chamber will not admit any animal larger than the foldiers or labourers. Hence the *king* and the *queen*, which laft, when full grown, is a thoufand times the weight of a king, can never poffibly go out. The royal chamber is furrounded by an innumerable quantity of others, which are of different fizes, figures, and dimenfions; but all of them are arched either in a circular or an elliptical form. Thefe chambers either open into each other, or have communicating paffages, which being always clear, are evidently intended for the conveniency of the foldiers and attendants, of whom, as will foon appear, great numbers are neceffary. Thefe apartments are joined by the magazines and nurferies. The magazines are chambers of clay, and are at all times well ftored with provifions, which, to the naked eye, feem to confift of the rafpings of wood and plants which the termites deftroy; but, when examined by the microfcope, they are found to confift chiefly of the gums or infpiffated juices of plants, thrown together in fmall irregular maffes. Of thefe maffes, fome are finer than others, and refemble the fugar about preferved fruits; others refemble the tears of gum, one being quite tranfparent, another like amber, a third brown, and a fourth perfectly opaque.

The magazines are always intermixed with the nurferies, which laft are buildings totally different from the reft of the apartments. They are compofed entirely of wooden materials, which feem to be cemented with gums. Mr Smeathman very properly gives them the appellation of *nurferies*; becaufe they are invariably occupied by the eggs, and the young ones, which firft appear in the fhape of labourers; but they are as white as fnow. Thefe buildings are exceedingly compact, and are divided into a number of fmall irregular-fhaped chambers, not one of which is half an inch wide. They are placed all round, and as near as poffible to the royal apartments.

When

When a neft or hillock is in the infant ftate, the nurferies are clofe to the royal apartment. But as, in procefs of time, the body of the queen enlarges, it becomes neceffary, for her accommodation, to augment the dimenfions of her chamber. She then, likewife, lays a greater number of eggs, and requires more attendants; of courfe, it is neceffary that both the number and dimenfions of the adjacent apartments fhould be augmented. For this purpofe, the fmall firft built nurferies are taken to pieces, rebuilt a little farther off, made a fize larger, and their number, at the fame time, is increafed. Thus the animals are continually employed in pulling down, repairing, or rebuilding their apartments; and thefe operations they perform with wonderful fagacity, regularity, and forefight.

One remarkable circumftance regarding the nurferies muft not be omitted. They are always flightly overgrown with a kind of *mould*, and plentifully fprinkled with white globules about the fize of a fmall pin's head. Thefe globules, Mr Smeathman at firft conjectured to be the eggs; but, when examined by the microfcope, they evidently appeared to be a fpecies of mufhroom, in fhape refembling our eatable mufhroom when young. When entire, they are white like fnow a little melted and frozen again; and, when bruifed, they feem to be compofed of an infinite number of pellucid particles, approaching to oval forms, and are with difficulty feparated from each other. The mouldinefs feems likewife to confift of the fame kind of fubftance *.

The

* Mr Konig, who examined the termites nefts in the Eaft Indies, conjectures, that thefe mufhrooms are the food of the young infects. This fuppofition implies, that the old ones have a method of providing for and promoting the growth of the mufhroom; 'a circumftance,' Mr Smeathman remarks, 'which, however ftrange to 'thofe unacquainted with the fagacity of thofe infects, I will venture to fay, from 'many other extraordinary facts I have feen of them, is not very improbable.'

The nurferies are enclofed in chambers of clay, like thofe which contain the provifions; but they are much larger. In the early ftate of the neft, they are not bigger than an hazel nut; but, in great hills, they are often as large as a child's head of a year old.

The royal chamber is fituated nearly on a level with the furface of the ground, at an equal diftance from all the fides of the building, and directly under the apex of the hill. On all fides, both above and below, it is furrounded by what are called the *royal apartments*, which contain only labourers and foldiers, who can be intended for no other purpofe than to continue in the neft either to guard or ferve their common *father* and *mother*, on whofe fafety the happinefs, and, in the eftimation of the Negroes, the exiftence of the whole community depends. Thefe apartments compofe an intricate labyrinth, which extends a foot or more in diameter from the *royal chamber* on every fide. Here the nurferies and magazines of provifions begin; and, being feparated by fmall empty chambers and galleries, which furround them, and communicate with each other, are continued on all fides to the outward fhell, and reach up within it two thirds or three-fourths of its height, leaving an open area in the middle under the dome, which refembles the nave of an old cathedral. This area is furrounded by large Gothic arches, which are fometimes two or three feet high next the front of the area, but diminifh rapidly as they recede, like the arches of aifles in perfpectives, and are foon loft among the innumerable chambers and nurferies behind them. All thefe chambers and paffages are arched, and contribute mutually to fupport one another. The interior building, or affemblage of nurferies, chambers, and paffages, has a flattifh roof without any perforation. By this contrivance, if, by accident, water fhould penetrate the external dome, the apartments below are preferved from injury. The area has alfo a flattifh floor, which is fituated above the royal chamber. It is likewife water-proof, and

fo

ſo conſtructed, that, if water gets admittance, it runs off by ſubterraneous paſſages, which are of an aſtoniſhing magnitude. 'I mea-'ſured one of them,' ſays Mr Smeathman, 'which was perfectly 'cylindrical, and thirteen inches in diameter.' Theſe ſubterraneous paſſages are thickly lined with the ſame kind of clay of which the hill is compoſed, aſcend the internal part of the external ſhell in a ſpiral form, and, winding round the whole building up to the top, interſect and communicate with each other at different heights. From every part of theſe large galleries a number of pipes, or ſmaller galleries, leading to different apartments of the building, proceed. There are likewiſe a great many which lead downward, by ſloping deſcents, three and four feet perpendicular under ground, among the gravel, from which the labouring termites ſelect the finer parts, which, after being worked up in their mouths to the conſiſtence of mortar, become that ſolid clay or ſtone of which their hills, and every apartment of their buildings, except the nurſeries, are compoſed. Other galleries aſcend and lead out horizontally on every ſide, and are carried under ground, but near the ſurface, to great diſtances. Suppoſe the whole neſts within a hundred yards of a houſe were completely deſtroyed, the inhabitants of thoſe at a greater diſtance will carry on their ſubterraneous galleries, and invade the goods and merchandizes contained in it by ſap and mine, unleſs great attention and circumſpection are employed by the proprietor.

Mr Smeathman concludes his deſcription of the habitations of the *termites bellicoſi*, with much modeſty, in the following words: 'Thus I have deſcribed, as briefly as the ſubject would admit, and I 'truſt without exaggeration, thoſe wonderful buildings, whoſe ſize, 'and external form, have often been mentioned by travellers, but 'whoſe interior, and moſt curious parts are ſo little known, that I 'may venture to conſider my account of them as new, which is the 'only merit it has; for they are conſtructed upon ſo different a plan 'from any thing elfe upon the earth, and fo complicated, that I can-'not find words equal to the tafk.'

When a breach is made in one of the hills by an ax, or other inftrument, the firft object that attracts attention is the behaviour of the foldiers, or fighting infects. Immediately after the blow is given, a foldier comes out, walks about the breach, and feems to examine the nature of the enemy, or the caufe of the attack. He then goes in to the hill, gives the alarm, and, in a fhort time, large bodies rufh out as faft as the breach will permit. It is not eafy to defcribe the fury thefe fighting infects difcover. In their eagernefs to repel the enemy, they frequently tumble down the fides of the hill, but recover themfelves very quickly, and bite every thing they encounter. This biting, joined to the ftriking of their forceps upon the building, makes a crackling or vibrating noife, which is fomewhat fhriller and quicker than the ticking of a watch, and may be heard at the diftance of three or four feet. While the attack proceeds, they are in the moft violent buftle and agitation. If they get hold of any part of a man's body, they inftantly make a wound, which difcharges as much blood as is equal to their own weight. When they attack the leg, the ftain of blood upon the ftocking extends more than an inch in width. They make their hooked jaws meet at the firft ftroke, and never quit their hold, but fuffer themfelves to be pulled away leg by leg, and piece after piece, without the fmalleft attempt to efcape. On the other hand, if a perfon keeps out of their reach, and gives them no farther difturbance, in lefs than half an hour they retire into the neft, as if they fuppofed the wonderful monfter that damaged their caftle had fled. Before the whole foldiers have got in, the labouring infects are all in motion, and haften toward the breach, each of them having a quantity of tempered mortar in his mouth. This mortar they ftick upon the breach as faft as they arrive, and perform the operation with fo much defpatch and facility,

lity, that, notwithftanding the immenfity of their numbers, they never ftop or embarrafs one another. During this fcene of apparent hurry and confufion, the fpectator is agreeably furprifed when he perceives a regular wall gradually arifing and filling up the chafm. While the labourers are thus employed, almoft all the foldiers remain within, except here and there one, who faunters about among fix hundred or a thoufand labourers, but never touches the mortar. One foldier, however, always takes his ftation clofe to the wall that the labourers are building. This foldier turns himfelf leifurely on all fides, and, at intervals of a minute or two, raifes his head, beats upon the building with his forceps, and makes the vibrating noife formerly mentioned. A loud hifs inftantly iffues from the infide of the dome and all the fubterraneous caverns and paffages. That this hifs proceeds from the labourers is apparent; for, at every fignal of this kind, they work with redoubled quicknefs and alacrity. A renewal of the attack, however, inftantly changes the fcene. 'On 'the firft ftroke,' Mr Smeathman remarks, 'the labourers run into 'the many pipes and galleries with which the building is perforated, 'which they do fo quickly, that they feem to vanifh; for in a few 'feconds all are gone, and the foldiers rufh out as numerous and as 'vindictive as before. On finding no enemy, they return again lei-'furely into the hill, and, very foon after, the labourers appear load-'ed as at firft, as active, and as fedulous, with foldiers here and 'there among them, who act juft in the fame manner, one or other 'of them giving the fignal to haften the bufinefs. Thus the plea-'fure of feeing them come out to fight or to work, alternately, may 'be obtained as often as curiofity excites, or time permits; and it 'will certainly be found, that the one order never attempts to fight, 'or the other to work, let the emergency be ever fo great.'

It is exceedingly difficult to explore the interior parts of a neft or hill. The apartments which furround the royal chamber and the

 nurferies,

nurſeries, and indeed the whole fabrick, have ſuch a dependence on each other, that the breaking of one arch generally pulls down two or three. There is another great obſtacle to our reſearches, namely, the obſtinacy of the ſoldiers, who, ſays our author, 'fight to the 'very laſt, diſputing every inch of ground ſo well as often to 'drive away the Negroes who are without ſhoes, and make white 'people bleed plentifully through their ſtockings. Neither can we 'let a building ſtand ſo as to get a view of the interior parts with- 'out interruption; for, while the ſoldiers are defending the out- 'works, the labourers keep barricading all the way againſt us, ſtop- 'ping up the different galleries and paſſages which lead to the vari- 'ous apartments, particularly the royal chamber, all the entrances to 'which they fill up ſo artfully as not to let it be diſtinguiſhable 'while it remains moiſt; and, externally, it has no other appearance 'than that of a ſhapeleſs lump of clay. It is, however, eaſily found 'from its ſituation with reſpect to the other parts of the building, 'and by the crowds of labourers and ſoldiers which ſurround it, who 'ſhow their loyalty and fidelity by dying under its walls. The roy- 'al chamber, in a large neſt, is capacious enough to hold many hun- 'dreds of the attendants, beſides the royal pair; and you always find 'it as full of them as it can hold. Theſe faithful ſubjects never 'abandon their charge even in the laſt diſtreſs; for, whenever I took 'out the royal chamber, and, as I often did, preſerved it for ſome 'time in a large glaſs bowl, all the attendants continued running in 'one direction round the king and queen with the utmoſt ſolicitude, 'ſome of them ſtopping at the head of the latter, as if to give her 'ſomething. When they came to the extremity of the abdomen, 'they took the eggs from her, and carried them away, and piled 'them carefully together in ſome part of the chamber, or in the 'bowl under, or behind any pieces of broken clay which lay moſt 'convenient for the purpoſe.'

In this chapter, I have given a ſuccinct view of the ſagacity, dexterity, and architectonic powers, exhibited in the conſtruction of habitations by the different claſſes of animals. But I am not without apprehenſions, that, in my endeavours to avoid prolixity, I may have, in ſome inſtances, degenerated into obſcurity. Enough, however, I hope, has been ſaid, either for the purpoſes of admiration or of reaſoning; and, therefore, I ſhall not anticipate the reflections of my readers, but proceed to the next ſubject.

CHAP.

CHAPTER XIV.

Of the Hoſtilities of Animals.

IN contemplating the ſyſtem of animation exhibited in this planet, the only one of which we have any extenſive knowledge, the mind is ſtruck, and even confounded, with the general ſcene of havock and devaſtation which is perpetually, and every where, preſented to our view. There is not, perhaps, a ſingle ſpecies of animated beings, whoſe exiſtence depends not, more or leſs, upon the death and deſtruction of others. Every animal, when not prematurely deprived of life by thoſe who are hoſtile to it, or by accident, enjoys a temporary exiſtence, the duration of which is longer or ſhorter according to its nature, and the rank it holds in the creation; and this exiſtence univerſally terminates in death and diſſolution. This is an eſtabliſhed law of Nature, to which every animal is obliged to ſubmit. But this neceſſary and univerſal deprivation of individual life, though great, is nothing when compared to the havock occaſioned by another law, which impels animals to kill and devour different ſpecies, and ſometimes their own. In the ſyſtem of Nature, death and diſſolution ſeem to be indiſpenſible for the ſupport and continuation of animal life.

But,

But, though almoſt every animal, in ſome meaſure, depends for its exiſtence on the deſtruction of others, there are ſome ſpecies in all the different tribes or claſſes, which are diſtinguiſhed by the appellation of *carnivorous* or *rapacious*, becauſe they live chiefly, or entirely, on animal food. In the proſecution of this ſubject, therefore, we ſhall, in the *firſt* place, mention ſome examples of animal hoſtility and rapacity; and, in the *next* place, endeavour to point out ſuch advantages as reſult from this apparently cruel inſtitution of Nature. On the laſt branch of the ſubject, however, the reader muſt not expect to have every difficulty removed, and every queſtion ſolved. Like all the other parts of the oeconomy of Nature, the neceſſity, or even the ſeeming cruelty and injuſtice, of allowing animals to prey upon one another, is a myſtery which we can never be enabled completely to unravel. But we are not entirely without hopes of ſhowing ſeveral important utilities which reſult from this almoſt univerſal ſcene of animal devaſtation.

Of all rapacious animals, *Man* is the moſt univerſal deſtroyer. The deſtruction of carnivorous quadrupeds, birds, and inſects, is, in general, limited to particular kinds. But the rapacity of man has hardly any limitation. His empire over the other animals which inhabit this globe is almoſt univerſal. He accordingly employs his power, and ſubdues or devours every ſpecies. Of ſome of the quadruped tribes, as the horſe, the dog, the cat, he makes domeſtic ſlaves; and, though in this country, none of theſe ſpecies is uſed for food, he either obliges them to labour for him, or keeps them as ſources of pleaſure and amuſement. From other quadrupeds, as the ox, the ſheep, the goat, and the deer kind, he derives innumerable advantages. The ox-kind, in particular, after receiving the emoluments of their labour and fertility, he rewards with death, and then feeds upon their carcaſſes. Many other ſpecies, though not commonly uſed as food, are daily maſſacred in millions for the purpoſes

of

of commerce, luxury, and caprice. Myriads of quadrupeds are annually deſtroyed for the ſake of their furs, their hides, their tuſks, their odoriferous ſecretions, &c.

Over the feathered tribes the dominion of man is not leſs extenſive. There is not a ſingle ſpecies in the numerous and diverſified claſs of birds, which he either does not, or may not, employ for the nouriſhment of his body. By his ſagacity and addreſs he has been enabled to domeſticate many of the more prolific and delicious ſpecies, as turkies, geeſe, and the various kinds of poultry. Theſe he multiplies without end, and devours at pleaſure.

Neither do the inhabitants of the waters eſcape the rapacity of man. Rivers, lakes, and even the ocean itſelf, feel the power of his empire, and are forced to ſupply him with proviſions. Neither air nor water can defend againſt the ingenuity, the art, and the deſtructive induſtry of the human ſpecies. Man may be ſaid even to have domeſticated ſome fiſhes. In artificial ponds, he feeds and rears carp, tench, perch, trout, and other ſpecies, and with them occaſionally furniſhes his table.

It might have been expected, that inſects and reptiles, ſome of which have a moſt diſguſting aſpect, would not have excited the human appetite. But we learn from experience, that, in every region of the earth, many inſects which inhabit both the earth and the waters, are eſteemed as delicate articles of luxury. Even the viper, though its venom be deleterious, eſcapes not the all-devouring jaws of man.

Thus man holds, and too often exerciſes, a tyrannical dominion over almoſt the whole brute creation, not becauſe he is the ſtrongeſt of all animals, but becauſe his intellect, though of a ſimilar nature,

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is vaftly fuperior to that of the moft fagacious of the lefs favoured tribes. He reigns over the other animals, becaufe, like them, he is not only endowed with fentiment, but becaufe the powers of his mind are more extenfive. He overcomes force by ingenuity, and fwiftnefs by art and perfevering induftry. But the empire of man over the brute creation is not abfolute. Some fpecies elude his power by the rapidity of their flight, by the fwiftnefs of their courfe, by the obfcurity of their retreats, and by the element in which they live. Others efcape him by the minutenefs of their bodies; and, inftead of acknowledging their fovereign, others boldly attack him with open hoftility. He is alfo infulted and injured by the ftings of infects, and by the poifonous bites of ferpents. In other refpects, man's empire, though comparatively great, is very much limited. He has no influence on the univerfe, on the motions and affections of the heavenly bodies, or on the revolutions of the globe which he inhabits. Neither has he a general dominion over animals, vegetables, or minerals. His power reaches not fpecies, but is confined to individuals. Every order of being moves on in its courfe, perifhes, or is renewed, by the irrefiftible power of Nature. Even man himfelf, hurried along by the general torrent of time and of Nature, cannot prolong his exiftence. He is obliged to fubmit to the univerfal law; and, like all other organized beings, he is born, grows to maturity, and dies. Though man has been enabled to fubdue the animal creation by the fuperior powers of his mind, his empire, like all other empires, could not be firmly eftablifhed previous to the inftitution of pretty numerous focieties. Almoft the whole of his power is derived from fociety. It matures his reafon, gives exertion to his genius, and unites his forces. Before the formation of large focieties, man was perhaps the moft helplefs and the leaft formidable of all animals. Naked, and deftitute of arms, to him the earth was only an immenfe defert peopled with ftrong and rapacious monfters, by whom he was often devoured. Even long after this period, hiſtory informs us, that the firſt heroes were deſtroyers of wild beaſts. But, after the human ſpecies had multiplied, and ſpread over the earth, and when, by means of ſociety and the arts, man was enabled to conquer a conſiderable part of the globe, he forced the wild beaſts gradually to retire to the deſerts. He cleared the earth of thoſe gigantic animals who, perhaps, now no longer exiſt, but whoſe enormous bones are ſtill found in different regions, and are preſerved in the cabinets of the curious. He reduced the numbers of the voracious and noxious ſpecies. He oppoſed the powers and the dexterity of one animal to thoſe of another. Some he ſubdued by addreſs, and others by force. In this manner he, in proceſs of time, acquired to himſelf perfect ſecurity, and eſtabliſhed an empire that has no other limits than inacceſſible ſolitudes, burning ſands, frozen mountains, or obſcure caverns, which are occupied as retreats by a few ſpecies of ferocious animals.

Next to *man*, the carnivorous *quadrupeds* are the moſt numerous and the moſt deſtructive. Different parts of the earth are infeſted with lions, tigers, panthers, ounces, leopards, jaguars, couguars, lynxes, wild cats, dogs, jackals, wolves, foxes, hyaenas, civets, genets, polecats, martins, ferrets, ermines, gluttons, bats, &c. Though all theſe, and many other tribes of quadrupeds, live ſolely upon blood and carnage, yet ſome of them, as the tiger, the wolf, the hyaena, and many other inferior ſpecies, are much more rapacious and deſtructive than others. The lion, though ſurrounded with prey, kills no more than he is able to conſume. But the tiger is groſsly ferocious, and cruel without neceſſity. Though ſatiated with carnage, he perpetually thirſts for blood. His reſtleſs fury has no intervals, except when he is obliged to lie in ambuſh for prey at the ſides of lakes or rivers, to which other animals reſort for drink. He ſeizes and tears in pieces a freſh animal with equal rage as he exerted in devouring the firſt. He deſolates every country that he inhabits, and

and dreads neither the aſpect nor the arms of man. He ſacrifices whole flocks of domeſtic animals, and all the wild beaſts which come within the reach of his terrible claws. He attacks the young of the elephant and rhinoceros, and ſometimes even ventures to brave the lion. His predominant inſtinct is a perpetual rage, a blind and undiſtinguiſhing ferocity, which often impel him to devour his own young, and to tear their mother in pieces when ſhe attempts to defend them. He delights in blood, and gluts himſelf with it till he is intoxicated. He tears the body for no other purpoſe than to plunge his head into it, and to drink large draughts of blood, the ſources of which are generally exhauſted before his thirſt is appeaſed. The tiger is perhaps the only animal whoſe ferocity is unconquerable. Neither violence, reſtraint, nor bribery, have any effect in ſoftening his temper. With harſh or gentle treatment he is equally irritated. The mild and conciliating influence of ſociety makes no impreſſion on the obduracy and incorrigibleneſs of his diſpoſition. Time, inſtead of ſoftening the ferociouſneſs of his nature, only exaſperates his rage. He tears, with equal wrath, the hand which feeds him, as that which is raiſed to ſtrike him. He roars and grins at the ſight of every living being. Every animated object he regards as a freſh prey, which he devours before hand with the avidity of his eyes, menaces it with frightful groans, and often ſprings at it, without regarding his chains, which only reſtrain, but cannot calm his fury.

In temperate climates, the wolf ſeems to exceed all other animals in the ferocity and rapacioufneſs of his diſpoſition. When preſſed with hunger, he braves every danger. He attacks all thoſe animals which are under the protection of man, eſpecially ſuch as he can carry off with eaſe, as lambs, kids, and the ſmaller kinds of dogs. When ſucceſsful in his expeditions, he returns often to the charge, till, after being chaced and wounded by men and dogs, he retires,

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during the day, to his den. In the night he again iſſues forth, traverſes the country, roams round the cottages, kills all the animals which have been left without, digs the earth under the doors, enters with a terrible ferocity, and puts every living creature to death, before he chooſes to depart, and carry off his prey. When theſe inroads happen to be fruitleſs, he returns to the woods, ſearches about with avidity, follows the track and the ſcent of wild beaſts, and purſues them till they fall a prey to his rapacity. In a word, when his hunger is extreme, he loſes all idea of fear, attacks women and children, and ſometimes men; at laſt he becomes perfectly furious by exceſſive exertions, and generally falls a ſacrifice to pure rage and diſtraction. When ſeveral wolves appear together, it is not an aſſociation of peace, but of war. It is attended with tumult and dreadful growlings, and indicates an attack upon ſome of the larger animals, as a ſtag, an ox, or a formidable maſtive. This depredatory expedition is no ſooner ended than they ſeparate, and every individual returns in ſilence to his ſolitude. Wolves are fond of human fleſh. They have been known to follow armies, to come in troops to the field of battle, where bodies are careleſsly interred, to tear them up, and to devour them with an inſatiable avidity: And, when once accuſtomed to human fleſh, theſe wolves ever after attack men, prefer the ſhepherd to the flock, devour women, and carry off children. Whole countries are ſometimes obliged to arm, in order to deſtroy the wolves. It is a fortunate circumſtance that theſe dangerous and deſtructive animals have been long totally extirpated from Great Britain and her iſlands.

Neither are the *feathered tribes* exempted from the general law of devaſtation. But the number of birds of prey, properly ſo called, is much leſs in proportion than that of carnivorous quadrupeds. Birds of prey are likewiſe weaker; and, of courſe, the deſtruction of animal life they occaſion is much more limited than the immenſe devaſtations devaftations daily committed by rapacious quadrupeds. But, as if tyranny never loft fight of its rights, great numbers of birds make prodigious depredations upon the inhabitants of the waters. A vaft tribe of birds frequent the waters, and live folely upon fifhes. In a certain fenfe, every fpecies of bird may be faid to be a bird of prey; for almoft the whole of them devour flies, worms, and other infects, either for food to themfelves or their young. Birds of prey, like carnivorous quadrupeds, are not fo prolific as the milder and more inoffenfive kinds. Moft of them lay only a fmall number of eggs. The great eagle and the ofprey produce only two eggs in a feafon. The pigeon, it may be faid, lays no more. But it fhould be confidered that the pigeon produces two eggs three, four, or five times, from fpring to autumn. All birds of prey exhibit an obduracy and a ferocioufnefs of difpofition, while the other kinds are mild, chearful, and gentle, in their afpect and manners. Moft birds of prey expel their offspring from the neft, and relinquifh them to their fate, before they are fufficiently able to provide for themfelves. This cruelty is the effect of perfonal want in the mother. When prey is fcanty, which often happens, fhe in a manner ftarves herfelf to fupport her young. But, when her hunger becomes exceffive, fhe forgets her parental affection, ftrikes, expels, and fometimes, in a paroxyfm of fury produced by want, kills her offspring. An averfion to fociety is another effect of this natural and acquired obduracy of temper. Birds of prey, as well as carnivorous quadrupeds, never affociate. Like robbers, they lead a folitary and wandering life. Mutual attachment unites the male and the female; and, as they are both capable of providing for themfelves, and can give mutual affiftance in making war againft other animals, they never feparate, even after the feafon of love The fame pair are uniformly found in the fame place; but they never affemble in flocks, nor even affociate in families. The larger kinds, as the eagles, require a greater quantity of food, and, for that reafon, never allow their own off-

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ſpring, after they have become rivals, to approach the places which the parents frequent. But all thoſe birds, and all thoſe quadrupeds, which are nouriſhed by the productions of the earth, live in families, are fond of ſociety, and aſſemble in numerous flocks, without quarrelling or diſturbing one another.

Both the earth and the air furniſh examples of rapacious animals. In theſe elements, however, the number of carnivorous animals is comparatively ſmall. But every inhabitant of the *waters* depends for its exiſtence upon rapine and deſtruction. The life of every *fiſh*, from the ſmalleſt to the greateſt, is one continued ſcene of hoſtility, violence, and evaſion. Their appetite for food is almoſt inſatiable. It impels them to encounter every danger. They are in continual motion; and the object of all their movements is to devour other fiſhes, or to avoid their own deſtruction. Their deſire for food is ſo keen and undiſtinguiſhing, that they greedily ſwallow every thing which has the appearance of animation. Thoſe that have ſmall mouths feed upon worms and the ſpawn of other fiſhes; and thoſe whoſe mouths are larger devour every animal, their own ſpecies not excepted, that can paſs through their gullet. To avoid deſtruction, the ſmaller fry retire to the ſhallows, where the larger kinds are unable to purſue them. But, in the watery element, no ſituation is abſolutely ſafe; for, even in the ſhallows, the oyſter, the ſcallop, and the muſcle, lie in ambuſh at the bottom, with their ſhells open, and, when a ſmall fiſh comes into contact with them, they inſtantly cloſe their ſhells upon him, and devour at leiſure their impriſoned prey. Neither is the hunting or purſuit of fiſhes confined to particular regions. Shoals of one ſpecies follow, with unwearied ardour, thoſe of another through vaſt tracts of the ocean. The cod purſues the whiting from the banks of Newfoundland to the ſouthern coſts of Spain.

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It is a remarkable circumftance in the hiftory of animated Nature, that carnivorous birds and quadrupeds are lefs prolific than the inoffenfive and affociating kinds; but, on the contrary, that the inhabitants of the waters, who are all carnivorous, are endowed with a moft aftonifhing fecundity. All kinds of fifhes, a few only excepted, are oviparous. Notwithftanding the amazing deftruction of their eggs by the fmaller fry that frequent the fhores, by aquatic birds, and by the larger fifhes, the numbers which efcape are fufficient to fupply the ocean with inhabitants, and to afford nourifhment to a very great portion of the human race. A cod, for inftance, according to the accurate computation of Lewenhoeck, produces, from one roe, above nine millions of eggs in a fingle feafon. The flounder lays annually above one million, and the mackarel more than five hundred thoufand: An increafe fo great, if permitted to arrive at maturity, that the ocean itfelf, in a few centuries, would not be fpacious enough to contain its animated productions. This wonderful fertility anfwers two valuable purpofes. In the midft of numberlefs enemies it continues the refpective fpecies, and furnifhes to all a proper quantity of nourifhment.

We have thus feen that man, fome quadrupeds, fome birds, and all fifhes, are carnivorous animals. But this fyftem of carnage defcends ftill lower. Many of the *infect* tribes derive their nourifhment from putrid carcaffes, from the bodies of living animals, or from killing and devouring weaker fpecies. How many flies are daily facrificed by fpiders, a moft voracious and a moft numerous tribe of infects? In return, fpeeders are greedily devoured by flies which are diftinguifhed by the name of *ichneumons*. The number of thefe ichneumon flies is inconceivable; and, if it were not for the prodigious havock they make upon caterpillars and other infects, the fruits of the earth would be entirely deftroyed. Wafps are extremely fond of animal food. They frequent butchers ftalls, and beat off the

the flefh fly, and every other infect that reforts thither for the purpofe of depofiting its eggs in the meat. Butchers take the advantage of this jealous warfare. They encourage the wafps, and make centinels of them, by giving them livers, which they prefer to more fibrous flefh, probably becaufe they can cut livers more eafily with their teeth.

The libella, dragon, or lady-fly, is well known by the beauty of its colours and the fymmetry of its form. For thefe external qualities it has received the appellation of *lady-fly*. Its difpofitions and its mode of life, however, are more ferocious and warlike than thofe of the Amazones. Like birds of prey, they hover about in the air, for the fole purpofe of devouring almoft every fpecies of winged infect. They accordingly frequent marfhy grounds, pools of water, and the margins of rivers, where infects moft abound. Their appetite is fo grofs and voracious, that they not only devour fmall flies, but even the large flefh-fly, moths, and butterflies, of every kind.

It has been often faid, that no animal fpontaneoufly feeds upon its own fpecies. This remark has probably been intended as an apology for, or at leaft a limitation to, the general fyftem of carnage eftablifhed by Nature. But the obfervation, whatever might have been its intention, is unhappily a refult of ignorance; for fome quadrupeds, all fifhes, and many infects, make no fuch difcrimination. The weaker are uniformly preyed upon by the ftronger. Reaumur put twenty of thofe caterpillars which feed upon the leaves of the oak into a vial. Though he regularly fupplied them with plenty of frefh oak leaves, he obferved that the number of dead ones daily increafed. Upon a more attentive examination into the caufe of this mortality, he found, that the ftronger attacked with their teeth, killed, fucked out the vitals of their weaker companions, and left nothing

thing but the head, feet, and empty ſkins. In a few days, one only of the twenty remained in life.

Caterpillars have myriads of external enemies, as birds of almoſt every kind, many of the ſmaller quadrupeds, their own ſpecies, and numberleſs inſects. But this vaſt ſource of devaſtation is ſtill augmented by what may be denominated their internal enemies. Many flies depoſit their eggs in the bodies of caterpillars. From theſe eggs proceed ſmall maggots, which gradually devour the vitals of the animal in which they reſide. When about to be transformed into chryſalids, they pierce the ſkin of the caterpillar, ſpin their pods, and remain on the empty ſkin till they aſſume the form of flies, and eſcape into the air to perform the ſame cruel office to another unfortunate reptile. Every perſon muſt recollect to have ſeen the colewort or cabbage caterpillar ſtuck upon old walls, or the windows of country cottages, totally covered with theſe chryſalids, which have the form of ſmall maggots, and are of a fine yellow colour. One of the moſt formidable enemies of the caterpillar is a black worm, with ſix cruſtaceous legs. It is as long, and thicker than an ordinary ſized caterpillar. In the fore part of the head it has two curved pincers, with which it quickly pierces the belly of a caterpillar, and never quits the prey till it is entirely devoured. The largeſt caterpillar is not ſufficient to nouriſh this worm for a ſingle day; for it daily kills and eats ſeveral of them. Theſe gluttonous worms, when gorged with food, become inactive, and almoſt motionleſs. When in this ſatiated condition, young worms of the ſame ſpecies attack and devour them. Of all trees, the oak, perhaps, nouriſhes the greateſt number of different caterpillars, as well as of different inſects. Amongſt others, the oak is inhabited by a large and beautiful beetle. This beetle frequents the oak, probably becauſe that tree is inhabited by the greateſt number of caterpillars. It marches from branch to branch, and, when difpofed for food, attacks and devours the firft caterpillar that comes in its way.

The pucerons, vine-fretters, or plant-lice, are very injurious to trees and vegetables of almoft every kind. Their fpecies are fo numerous, and all of them are endowed with fuch a wonderful fertility, that we fhould expect to fee the leaves, the branches, and the ftems of every plant totally covered with them. But this aftonifhing fecundity, and the devaftation thefe fmall infects would unavoidably produce among the vegetable tribes, is checked by numberlefs enemies. Myriads of infects of different claffes, of different genera, and of different fpecies, feem to be produced for no other purpofe but to devour the pucerons. Some of thefe infects are fo voracious, that, notwithftanding the extreme prolific powers of the pucerons, we have reafon to be furprifed that their fpecies are not entirely annihilated. On every leaf inhabited by the puceron we find worms of different kinds. Thefe worms feed not upon the leaves, but upon the pucerons, whom they devour with an almoft incredible rapacity. Some of thefe worms are transformed into flies with two wings, others into flies with four wings, and others into beetles. While in the worm-ftate, one of thefe gluttonous infects will fuck out the vitals of twenty pucerons in a quarter of an hour. Reaumur fupplied a fingle worm with more than a hundred pucerons, every one of which it devoured in lefs than three hours.

Befide the general fyftem of carnage produced by the neceffity of one animal's feeding upon another, there are other fources of deftruction, which originate from very different motives. Man is not the only animal who wages war with his own fpecies. War among mankind, in certain accidental fituations of fociety, may be productive, to particular nations or communities, of beneficial effects. But every advantage derived by war to one nation is acquired at the expence,

pence, and either the partial or the total ruin of another. If universal peace could be completely eftabliſhed, and if the earth were cultivated to the higheft perfection, it is not probable that the multiplication of the human ſpecies would ever riſe to ſuch a degree as to exceed the quantity of proviſions produced by agriculture, and by the breeding of domeftic animals, neceſſary for their exiftence and happineſs. But, as long as men are actuated by ambition, by reſentment, and by many other hoftile paſſions, war and animoſity, with all their train of blood-ſhed and calamity, will forever continue to harraſs and perſecute the human kind. Let us, however, be humble. We cannot unfold the myfteries of Nature; but we may admire her operations, and ſubmit, with a becoming reſignation, to her irreſiftible decrees. The man, if ſuch a man there be, whoſe ftrength of mind enables him to obſerve fteadfaftly this conduct, is the only real philoſopher.

As formerly remarked, man is not the only animal that makes war with his own ſpecies. Quadrupeds, birds, fiſhes, inſects, independently of their appetite for food, occaſionally fight and kill each other. On this ſubject we ſhall confine ourſelves to a few examples derived from the inſect tribes.

A ſociety or hive of bees conſifts of a female, of males, and of drones, or neuters. Theſe three kinds continue, for ſome time, in the moft perfect harmony, and mutually protect and aſſift each other. The neuters, or working bees, diſcover the ftrongeft attachment and affection to the males, even when in their worm ftate. The neuters are armed with a deadly fting, of which the males are deftitute. Both are equally produced by the ſame mother, and live in the ſame family. But, notwithftanding their temporary affection, there are times when the neuters cruelly maſſacre the males. Among the laws of poliſhed republics, we find ſome which are extremely barbarous.

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The Lacedemonians were allowed to kill ſuch of their children as were produced in a defective or maimed ſtate, becauſe they would become a burden upon the community. The laws of the Chineſe permit actions equally inhuman. We perhaps know not all the reaſons why the neuter bees treat the males with ſo much cruelty. There is a time, however, when the males become perfectly uſeleſs to the community; and it is not incurious to remark, that the general maſſacre never commences till this period arrives. Whenever a ſtranger bee enters a hive, his temerity is uniformly puniſhed with death. But mortal combats are not unfrequent between bees belonging to the ſame hive. Theſe combats are moſt frequent in clear and warm weather. Sometimes two combatants come out of the hive cloſely faſtened to each other. At other times the attack is made in the air. But, in whatever way the battle begins, both combatants uniformly come to the ground before it is terminated by the death of one of the parties. When they reach the ground, each individual, like a wreſtler, endeavours to gain the moſt advantageous poſition for ſtinging his adverſary to death. Sometimes, though rarely, the ſting is left in the wound. If this were generally the caſe, every combat would prove fatal to two bees; for the victor could not long ſurvive the loſs of his ſting. Theſe battles ſometimes continue near an hour before one of the flies is left expiring on the ground.

Beſide theſe ſingle combats, general actions are not unfrequent, eſpecially in the ſwarming ſeaſon. When two ſwarms, or colonies, happen to contend for the ſame habitation, a general and bloody engagement immediately enſues. Theſe engagements often continue for hours, and never terminate without great havock on both ſides. The ſting is not the only weapon employed in war by bees. They are furniſhed with two ſtrong fangs or teeth, with which they cruelly tear each other. Even in general engagements, all the combats

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are ſingle. But, when the great ſlaughter of the males is committing, three or four neuters are not aſhamed to attack a ſingle fly.

Every waſp's neſt, about the beginning of October, exhibits a ſingular and a cruel ſcene. At this ſeaſon, the waſps ceaſe to bring nouriſhment to their young. From affectionate mothers or nurſes, they at once become barbarous ſtepmothers. They are worſe; for they drag the young worms from their cells, and carry them out of the neſt. Being thus expoſed to the weather, and deprived of nouriſhment, every one of them unavoidably periſhes. This devaſtation is not, like that of the honey-bees, confined to the male-worms. Here no worm, of whatever denomination or ſex, eſcapes the general and undiſtinguiſhing maſſacre. Beſide expoſing the worms to the weather, the waſps kill them with their fangs. This fact ſeems to be a violation of parental affection, one of the ſtrongeſt principles in animal nature. But the intentions of Nature, though they may often elude our reſearches, are never wrong. What appears to us cruel and unnatural in this inſtinctive devaſtation committed annually by the waſps, is perhaps an act of the greateſt mercy and compaſſion. Waſps are not, like the honey-bees, endowed with the inſtinct of laying up a ſtore of proviſions for winter ſubſiſtence. If not prematurely deſtroyed by their parents, the young muſt neceſſarily die a more cruel and lingering death, occaſioned by hunger. Hence this ſeemingly harſh conduct in the oeconomy of waſps, inſtead of affording an exception to the univerſal benevolence and wiſdom of Nature, is, in reality, a merciful inſtitution. Beſides, as the multiplication of waſps is prodigious, and as they are a noxious race both to man and other animals, and eſpecially to many tribes of inſects, if their increaſe were not checked by ſuch a dreadful carnage, their depredations, in a few years, would annihilate other ſpecies, break the chain of Nature, and even prove deſtructive to man and the larger animals.

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The ſame inſtinctive ſlaughter, and probably for the ſame reaſons, is made by the hornets. Towards the end of October, all the worms and nymphs are dragged out of the neſt and killed. The neuters and males fall daily victims to the cold; ſo that, at the end of winter, a few fertile females only remain to continue the ſpecies.

According to the adopted plan, we ſhall finiſh this ſubject with ſome obſervations which may have a tendency to reconcile our minds to a ſyſtem ſo deſtructive to individuals of every ſpecies, that humanity, when not enlightened by a ray of philoſophy, is apt to revolt, and to brand Nature with cruelty and oppreſſion. Nature, it muſt be confeſſed, ſeems almoſt indifferent to individuals, who periſh every moment in millions, without any apparent compunction. But, with regard to ſpecies of every deſcription, her uniform and uninterrupted attention to the preſervation and continuation of the great ſyſtem of animation is conſpicuous, and merits admiration. Life, it ſhould appear, cannot be ſupported without the intervention of death. Through almoſt the whole of animated Nature, as we have ſeen, nothing but rapine, and the deſtruction of individuals, prevail. This deſtruction, however, has its uſe. Every animal, after death, adminiſters life and happineſs to a number of others. In many animals, the powers of digeſtion, and of aſſimilation, are confined to animal ſubſtances alone. If deprived of animal food, ſuch ſpecies, it is evident, could not exiſt. The chief force of this obſervation, it is admitted, is applicable ſolely to the carnivorous tribes, ſtrictly ſo denominated. But, from the facts formerly enumerated, and from the daily experience of every man, it is apparent, that, perhaps, no animal does or can exiſt totally independent of food that is or has been animated. Sheep, oxen, and all herbivorous animals, though not from choice, and even without conſcioufneſs, daily devour thouſands of inſects. This may be one reaſon why cattle of all kinds fatten ſo remarkably in rich paſtures; for inſects are always

moſt

moſt numerous where the herbage is luxuriant. Nature is ſo profuſe in her animated productions, that no food can be eat, and no fluid can be drunk, in which animal ſubſtances, either in a living or dead ſtate, are not to be found.

To this reaſoning it may be objected, Why has Nature eſtabliſhed a ſyſtem ſo cruel? Why did ſhe render it neceſſary that one animal could not live without the deſtruction of another? To ſuch queſtions no anſwer can be either given or expected. No being, except the Supreme, can unfold this myſtery. Perhaps it even exceeds the limits of poſſibility to eſtabliſh ſuch an extended ſyſtem of animation upon any other foundation. From the general benevolence of the great Creator, we are warranted to conclude that this is really the caſe. But it is fruitleſs to dwell upon ſubjects which are inſcrutable, and far removed beyond the powers of human intellect. We ſhall therefore deſcend, and endeavour to point out ſome advantages which reſult from this myſterious inſtitution of Nature.

On this branch of the ſubject, the reader will eaſily perceive that much order or connection is not to be expected.

The hoſtilities of animals, mankind not excepted, give riſe to mutual improvement. Animals improve, and diſcover a ſuperiority of parts, in proportion to the number of enemies they have to attack or evade. The weak, and conſequently timid, are obliged to exert their utmoſt powers in inventing and practiſing every poſſible mode of eſcape. Pure inſtinct powerfully prompts; but much is learned by experience and obſervation. Rapacious animals, on the contrary, by frequent diſappointment, are obliged to provide againſt the cunning and alertneſs of their prey. Herbivorous animals, as they have little difficulty in procuring food, are proportionally ſtupid; but they would be ſtill more ſtupid, if they had no enemies to annoy them.

Man,

Man, if his attention and talents were not excited by the animoſities of his own ſpecies, by the attacks of ferocious animals, and even by thoſe of the inſect tribes, would be an indolent, an incurious, a dirty, and an ignorant animal. Thoſe of the human race, accordingly, who procure their food with little or no induſtry, as we learn from a multitude of travellers and voyagers, are perfectly indolent and brutiſhly ſtupid. Timid animals never uſe the arts of defence, or provide againſt danger, except from three cauſes, pure inſtinct, which is implanted in their natures, imitation, and experience. By experience, timid animals are taught the arts of evaſion. Flight is inſtinctive; but the modifications of it are acquired by imitation and experience.

Hoſtilities, in ſome inſtances, ſeem to ariſe, not from a natural antipathy of one ſpecies to another, but from a ſcarcity of food. The celebrated Captain Cooke informs us, that, in Staten Iſland, birds of prey aſſemble promiſcuouſly with penguins and other birds, without the one offering any injury, or the other diſcovering the ſmalleſt ſymptom of terror. In that iſland, the rapacious birds, perhaps, find plenty of food from dead ſeals, ſea-lions, and fiſhes.

A profuſion of animal life ſeems to be the general intention of Nature. For this purpoſe, when not modified or reſtrained by the induſtry and intelligence of man, ſhe uniformly covers the ſurface of the earth with trees and vegetables of every kind, which ſupply myriads of animated beings with food. But the greateſt poſſible extention of life would ſtill be wanting, if animals did not prey upon each other. If all animals were to live upon vegetables alone, many ſpecies, and millions of individuals, which now enjoy life and happineſs, could have no exiſtence; for the productions of the earth would not be ſufficient to ſupport them. But, by making animals feed upon each other, the ſyſtem of animation and of happineſs is extended

extended to the greateſt poſſible degree. In this view, Nature, inſtead of being cruel and oppreſſive, is highly generous and beneficent.

To diminiſh the number of noxious animals, and to augment that of uſeful vegetables, has been the uniform ſcope of human induſtry. A few ſpecies of animals only are of immediate utility to man. Theſe he either cultivates with care, or hunts for his prey. The ox, the ſheep, the goat, and other animals which are under his peculiar protection, he daily uſes for food. This is not cruelty. He has a right to eat them: For, like Nature, though he occaſionally deſtroys domeſtic animals, a timid and docile race of beings, by his culture and protection he gives life and happineſs to millions, which, without his aid, could have no exiſtence. The number of individuals, among animals of this deſcription, if they were not cheriſhed and defended by man, would be extremely limited; for, by the mildneſs of their diſpoſitions, the comparative weakneſs of their arms, and the univerſal and ſtrong appetite for them by rapacious quadrupeds and birds of prey, though the ſpecies might, perhaps, be continued, the number of individuals would, of neceſſity, be very ſmall.

There is a wonderful balance in the ſyſtem of animal deſtruction. If the general profuſion of the animated productions of Nature had no other check than the various periods to which their lives, when not extinguiſhed by hoſtilities of one kind or another, are limited, the whole would ſoon be annihilated by an univerſal famine, and the earth, inſtead of every where teeming with animals, would, unleſs re-peopled by a new creation, exhibit nothing but a mute, a lifeleſs, and an inactive ſcene. If even a ſingle ſpecies were permitted to multiply without diſturbance, the food of other ſpecies would be exhauſted, and, of courſe, a period would be put to their exiſtence. The herbivorous and frugivorous races, if not reſtrained by the carnivorous, would ſoon increaſe to a hurtful degree. Carnivorous animals are the barriers fixed by Nature to noxious inundations of other kinds. The carnivorous tribes may be compared to the hoe and the pruning hook, which, by diminiſhing the number of plants when too cloſe, or lopping off their luxuriancies, make the others grow to greater perfection. To thoſe ſwarms of inſects which cover the ſurface of the earth, are oppoſed an army of birds, an active, a vigilant, and a voracious race. Hares, rabbits, mice, rats, are expoſed to the depredations of carnivorous quadrupeds and birds. The larger cattle, as the ox, the deer, the ſheep, &c. are not exempted from enemies: And man, by the ſuperiority of his mental powers, checks the multiplication of the carnivorous tribes, and maintains the balance and empire of the animal ſyſtem. Thoſe ſpecies which are endowed with uncommon fertility have the greateſt number of enemies. The caterpillar, the puceron, and inſects in general, one of the moſt prolific tribes of animals, are attacked and devoured by numerous hoſtile bands. No ſpecies, however, is ever exhauſted. The balance between gain and loſs is perpetually preſerved. The earth, the ſeas, the atmoſphere, may be conſidered as an immenſe and variegated paſture. In this view, it is moſt judiciouſly cultivated and ſtocked by the numerous animated beings which it is deſtined to ſupport. Every animal and every vegetable furniſh ſubſiſtence to particular ſpecies. Thus, nothing of value is loſt; and every ſpecies is abundantly ſupplied with food.

That the general balance of animation is conſtantly preſerved, we learn from daily experience. The reader, however, I preſume, will not be diſpleaſed to have ſome examples of the modes employed by Nature to accompliſh this effect ſuggeſted to him.

After an inundation of the Nile, the lower parts of Egypt are greatly infeſted with ſerpents, frogs, mice, and other vermin. At that

that period, the ftorks refort thither in immenfe multitudes, and devour the ferpents, frogs, and mice, which, without this dreadful carnage, would be highly noxious to the inhabitants. Belon, a moft ingenious and faithful French naturalift, remarks, that, in many places, the land could not be inhabited, if the ftorks did not deftroy the amazing numbers of mice which frequently appear in Paleftine, and other parts of the Eaft bordering upon Egypt. The Egyptian vulture, fays Haffelquift, is of fingular benefit to that country. It eats up all the dung and off-falls in the towns, and the carcaffes of camels, horfes, affes, &c. in the fields, which, if not quickly devoured, would, in that warm climate, by their putrefcency, be productive of difeafe and death to the inhabitants. Putrid carcaffes, in all countries, are both offenfive to the noftrils and hurtful to health. But Nature, by various inftruments, foon removes the evil. An animal no fooner dies, than, in a very fhort time, he is confumed by bears, wolves, foxes, dogs, and ravens. In fituations where thefe animals dare not approach, as in the vicinity of towns and villages, a dead horfe, in a few days, is devoured by myriads of maggots. In the uncultivated parts of America, ferpents and fnakes of different kinds abound. After it was difcovered that fwine greedily devoured ferpents, hogs were uniformly kept by all new fettlers. Caterpillars are deftructive to the leaves and fruits of plants. Their numbers and varieties are immenfe. But their devaftations are checked by many enemies. Without a profufion of caterpillars, moft of the fmaller birds, efpecially when young, could not be fupported. By devouring the caterpillars, thefe birds preferve the fruits of the earth from total deftruction. Mr Bradley, in his general treatife of hufbandry and gardening, has publifhed a letter, in which the author oppofes the common opinion, that birds, and particularly fparrows, do much mifchief in our gardens and fields. The fact is admitted. But the great utility of thefe birds is overlooked: For this author proves, that they are much more ufeful than noxious. He fhows, that a pair of ſparrows, during the time they have their young to feed, deſtroy, every week, 3360 caterpillars. This calculation he founded upon actual obſervation. He diſcovered that the two parents carried to the neſt 40 caterpillars in an hour. He then ſuppoſes, which is a moderate ſuppoſition, that the ſparrows enter the neſt only 12 hours each day, which is a daily conſumption of 480 caterpillars. This ſum, multiplied by 7, or the days of a week, gives 3360 caterpillars extirpated weekly from a garden. The utility of theſe birds is not limited to this circumſtance alone; for they likewiſe feed their young with butterflies, and other winged inſects, each of which, if not deſtroyed in this manner, would be the parent of ſeveral hundreds of caterpillars. Thoſe butterflies and caterpillars which are covered with hair are rejected by ſome birds, who prefer flies of a ſmoother and ſmaller kind. But theſe hairy ſpecies, it ſhould be conſidered, are the food of the worms which are transformed into thoſe ſmaller flies that afford nouriſhment to the birds which reject the hairy caterpillars and butterflies.

Shell-fiſhes are extremely prolific, and ſo ſtrongly fortified by Nature, that their increaſe, one ſhould imagine, would ſoon augment to a degree that might be hurtful to other ſpecies. Their noxious multiplication, however, is checked by numberleſs enemies. But their moſt deſtructive enemy is the trochus, which is a kind of ſea-ſnail. This animal is furniſhed with a ſtrong, muſcular, hollow trunk, bordered at the extremity with a cartilage toothed like a ſaw. Againſt this inſtrument, which acts like an augre, no ſhell, however hard or thick, is a ſufficient defence. Theſe animals, called *trochi*, fix themſelves upon an oyſter or a muſcle, bore through the ſhell with their trunk, and devour their prey at their leiſure. The animal attacked, if a bivalve, may open or ſhut its ſhell; but no efforts of this kind can be of any avail; for the trochus remains immoveably fixed till it has completely ſucked out the vitals of its prey. In this cruel occupation

cupation the trochus often continues for days, and even weeks, before the life of the animal attacked is fully extinguifhed. The operation of the trochus may be feen in the fhells of many oyfters, mufcles, and other fhell-fifhes; for their fhells are often pierced with a number of circular holes.

The amazing fize and ftrength of the whale, one fhould imagine, would fecure it from the infults of every other animal. But, befide the annual depredations made by man upon the cetaceous tribes, they are often attacked and killed by the fword-fifh. The fnout of this comparatively fmall animal is armed with a long, hard, projection of bone, each edge of which is furnifhed with a number of ftrong, flat, and fharp points, or teeth, fome of which, efpecially near the fnout, are an inch and a half in length. With this inftrument the fword-fifh boldly attacks the whale. I have often had the pleafure, fays Pere Labat *, of feeing their combats. The whale has no other defence but its tail, with which it endeavours to ftrike its antagonift. But, as the fword-fifh is more active and nimble than the whale, he eafily parries the blow by fpringing into the air, and renewing the attack with his faw-like inftrument. Whenever he fucceeds, the fea is dyed red with the blood iffuing from the wound. The fury of the whale appears from the vehemence with which it lafhes the waters, each ftroke refounding like the report of a cannon.

Many fmall birds, and particularly the wren and the tit-moufe, may be feen, during the winter-feafon, pecking at the buds and branches of trees in our gardens. To thefe little animals Nature has entrufted the charge of preventing the noxious multiplication of thofe worms which feed upon fruits. Nature, as far as we are able to

* Nouv. Voyage, tom. 6. pag. 150.

to trace her operations, does nothing in vain, or without ſome valuable intention. No animals exiſt which are not uſeful, either by affording nouriſhment to, or preventing the hurtful increaſe of other ſpecies.

Upon the whole, every animated being that inhabits this globe ſeems to be deſtined by Nature, not for its own individual exiſtence and happineſs alone, but likewiſe for the exiſtence and happineſs of other animated beings. A circle of animation and of deſtruction goes perpetually round. This is the oeconomy of Nature. Different ſpecies of animals live by the mutual deſtruction of each other. Even among individual men, the ſtrong too often oppreſs the weak; but, on the other hand, the wiſe inſtruct the ignorant. Theſe are the bonds of ſociety, and the ſources of improvement.

CHAP.

CHAPTER XV.

Of the Artifices of Animals.

IT will be recollected, that many inftances of the dexterity and artifices employed by different animals in various parts of their manners and oeconomy, have been occafionally mentioned in feveral of the foregoing chapters. This circumftance, to avoid repetitions, will neceffarily render the prefent chapter proportionally fhort.

The artifices practifed by animals proceed from feveral motives, many of which are purely inftinctive, and others are acquired by experience and imitation. Their arts, in general, are called forth and exerted by three great and important caufes, the love of life, the defire of multiplying and continuing the fpecies, and that ftrong attachment which every animal has to its offspring. Thefe are the fources from which all the movements, all the dexterity, and all the fagacity of animals originate. The principle of felf-prefervation is inftinctive, and ftrongly impreffed upon the minds of all animated beings. It gives rife to innumerable arts of attack and defence, and not unfrequently to furprifing exertions of fagacity and genius. The fame remark is applicable to the defire of multiplication, and to parental affection. Upon this fubject we fhall, as ufual, give fome examples

amples of animal artifice, which may both amufe and inform fome readers.

When a bear, or other rapacious animal, attacks cattle, they inftantly join and form a phalanx for mutual defence. In the fame circumftances, horfes rank up in lines, and beat off the enemy with their heels. Pontopidon tells us, that the fmall Norwegian horfes, when attacked by bears, inftead of ftriking with their hind-legs, rear, and, by quick and repeated ftrokes with their fore-feet, either kill the enemy, or oblige him to retire. This curious, and generally fuccefsful defence, is frequently performed in the woods, while a traveller is fitting on the horfe's back. It has often been remarked, that troops of wild horfes, when fleeping either in plains or in the foreft, have always one of their number awake, who acts as a centinel, and gives notice of any approaching danger.

Margraaf informs us, that the monkeys in Brazil, while they are fleeping on the trees, have uniformly a centinel to warn them of the approach of the tiger or other rapacious animals; and that, if ever this centinel is found fleeping, his companions inftantly tear him in pieces for his neglect of duty. For the fame purpofe, when a troop of monkeys are committing depredations on the fruits of a garden, a centinel is placed on an eminence, who, when any perfon appears, makes a certain chattering noife, which the reft underftand to be a fignal for retreat, and immediately fly off and make their efcape.

The deer-kind are remarkable for the arts they employ in order to deceive the dogs. With this view the ftag often returns twice or thrice upon his former fteps. He endeavours to raife hinds or younger ftags to follow him, and to draw off the dogs from the immediate object of their purfuit. If he fucceeds in this attempt, he then flies off with redoubled fpeed, or fprings off at a fide, and lies

down

down on his belly to conceal himſelf. When in this ſituation, if by any means his foot is recovered by the dogs, they purſue him with more advantage, becauſe he is now conſiderably fatigued. Their ardour increaſes in proportion to his feebleneſs; and the ſcent becomes ſtronger as he grows warm. From theſe circumſtances the dogs augment their cries and their ſpeed; and, though the ſtag employs more arts of eſcape than formerly, as his ſwiftneſs is diminiſhed, his doublings and artifices become gradually leſs effectual. No other reſource is now left him but to fly from the earth which he treads, and go into the waters, in order to cut off the ſcent from the dogs, when the huntſmen again endeavour to put them on the track of his foot. After taking to the water, the ſtag is ſo much exhauſted that he is incapable of running much farther, and is ſoon *at bay*, or, in other words, turns and defends himſelf againſt the hounds. In this ſituation he often wounds the dogs, and even the huntſmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life. The fallow-deer is more delicate, leſs ſavage, and approaches nearer to the domeſtic ſtate than the ſtag. The males, during the rutting ſeaſon, make a bellowing noiſe, but with a low and interrupted voice. They are not ſo furious as the ſtag. They never depart from their own country in queſt of females; but they bravely fight for the poſſeſſion of their miſtreſſes. They aſſociate in herds, which generally keep together. When great numbers are aſſembled in one park, they commonly form themſelves into two diſtinct troops, which ſoon become hoſtile, becauſe they are both ambitious of poſſeſſing the ſame part of the incloſure. Each of theſe troops has its own chief or leader, who always marches foremoſt, and he is uniformly the oldeſt and ſtrongeſt of the flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who obſerve the ſame conduct, from the beſt paſture. The regularity with which theſe combats are conducted is ſingular. They make regular attacks, fight with courage, and never think themfelves vanquifhed by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worft pafture. They love elevated and hilly countries. When hunted, they run not ftraight out, like the ftag, but double, and endeavour to conceal themfelves from the dogs by various artifices, and by fubftituting other animals in their place. When fatigued and heated, however, they take the water, but never attempt to crofs fuch large rivers as the ftag. Thus, between the chace of the fallow-deer and of the ftag, there is no material difference. Their fagacity and inftincts, their fhifts and doublings, are the fame, only they are more frequently practifed by the fallow-deer. As he runs not fo far before the dogs, and is lefs enterprifing, he has oftener occafion to change, to fubftitute another in his place, to double, return upon his former tracks, &c. which renders the hunting of the fallow-deer more fubject to inconveniencies than that of the ftag.

The roe-deer is inferior to the ftag and fallow-deer both in ftrength and ftature; but he is endowed with more gracefulnefs, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewife more crafty, conceals himfelf with greater addrefs, and derives fuperior refources from his inftincts. Though he leaves behind him a ftronger fcent than the ftag, which increafes the ardour of the dogs, he knows how to evade their purfuit, by the rapidity with which he commences his flight, and by his numerous doublings. He delays not his arts of defence till his ftrength begins to fail him; for he no fooner perceives that the firft efforts of a rapid flight have been unfuccefsful, than he repeatedly returns upon his former fteps; and, after confounding, by thefe oppofite motions, the direction he has taken, after intermixing the prefent with the paft emanations of his body,

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he, by a great bound, rifes from the earth, and, retiring to a fide, lies down flat on his belly. In this immoveable fituation, he often allows the whole pack of his deceived enemies to pafs very near him. The roe-deer differs from the ftag in difpofition, manners, and in almoft every natural habit. Inftead of affociating in herds, they live in feparate families. The two parents and the young go together, and never mingle with ftrangers. They are conftant in their amours, and never unfaithful like the ftag. The females commonly produce two fawns, the one a male and the other a female. Thefe young animals, who are brought up and nourifhed together, acquire a mutual affection fo ftrong, that they never depart from each other. This attachment is fomething more than love; for, though always in company, they feel the rut but once a year, and it continues only fifteen days. At this period the father drives off the fawns, as if he intended that they fhould yield their place to thofe which are to fucceed, in order to form new families for themfelves. After the rutting feafon, however, is paft, the fawns return to their mother, and continue with her fome time longer; after which they feparate forever, and remove to a diftance from the place of their nativity. When about to bring forth, the female feparates from the male; and, to avoid the wolf, her moft dangerous enemy, conceals herfelf in the deepeft receffes of the foreft. In a week or two the fawns are able to follow her. When threatened with danger, fhe hides them in a clofe thicket; and, fo ftrong is her parental affection, that, in order to preferve her offspring from deftruction, fhe prefents herfelf to be chaced.

Hares poffefs not, like rabbits, the art of digging retreats in the earth. But they neither want inftinct fufficient for their own prefervation, nor fagacity for efcaping their enemies. They form feats or nefts on the furface of the ground, where they watch, with the moft vigilant attention, the approach of any danger. In order to

 deceive,

deceive, they conceal themſelves between clods of the ſame colour with that of their own hair. When purſued, they firſt run with rapidity, and then double, or return upon their former ſteps. From the place of ſtarting, the females run not ſo far as the males; but they double more frequently. Hares hunted in the place where they were brought forth, ſeldom remove to a great diſtance from it, but return to their form; and, when chaced two days ſucceſſively, on the ſecond day they perform the ſame doublings they had practiſed the day before. When hares run ſtraight out to a great diſtance, it is a proof that they are ſtrangers. Male hares, eſpecially during the moſt remarkable period of rutting, which is in the months of January, February, and March, ſometimes perform journies of ſeveral miles in queſt of mates; but, as ſoon as they are ſtarted by dogs, they fly back to the place of their nativity. 'I have ſeen a hare,' Fouilloux remarks, 'ſo ſagacious, that, after hearing the hunter's horn, he 'ſtarted from his form, and, though at the diſtance of a quarter of a 'league, went to ſwim in a pool, and lay down on the ruſhes in the 'middle of it, without being chaced by the dogs. I have ſeen a 'hare, after running two hours before the dogs, puſh another from 'his ſeat, and take poſſeſſion of it. I have ſeen others ſwim over 'two or three ponds, the narroweſt of which was eighty paces broad. 'I have ſeen others, after a two hours chace, run into a ſheep-fold 'and lie down among them. I have ſeen others, when hard puſhed, 'run in among a flock of ſheep, and would not leave them. I have 'ſeen others, after hearing the noiſe of the hounds, conceal them'ſelves in the earth. I have ſeen others run up one ſide of a hedge 'and return by the other, when there was nothing elſe between them 'and the dogs. I have ſeen others, after running half an hour, 'mount an old wall, ſix feet high, and clap down in a hole covered 'with ivy. Laſtly, I have ſeen others ſwim over a river, of about 'eighty paces broad, oftener than twice, in the length of two hun'dred paces.'

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The fox has, in all ages and nations, been celebrated for craftinefs and addrefs. Acute and circumfpect, fagacious and prudent, he diverfifies his conduct, and always referves fome art for unforefeen accidents. Though nimbler than the wolf, he trufts not entirely to the fwiftnefs of his courfe. He knows how to enfure fafety, by providing himfelf with an afylum, to which he retires when danger appears. He is not a vagabond, but lives in a fettled habitation and in a domeftic ftate. The choice of fituation, the art of making and rendering a houfe commodious, and of concealing the avenues which lead to it, imply a fuperior degree of fentiment and reflection. The fox poffeffes thefe qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he liftens to the crowing of the cocks and the noife of the poultry. He fcents them at a diftance. He choofes his time with great judgment and difcretion. He conceals both his route and his defign. He moves forward with caution, fometimes even trailing his body, and feldom makes a fruitlefs expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the fowls to death, and then retires quietly with his prey, which he either conceals under the herbage, or carries off to his kennel. In a fhort time he returns for another, which he carries off and hides in the fame manner, but in a different place. In this manner he proceeds, till the light of the fun, or fome movements perceived in the houfe, admonifh him that it is time to retire to his den. He does much mifchief to the bird-catchers. Early in the morning he vifits their nets and their bird-lime, and carries off fucceffively all the birds that happen to be entangled. The young hares he hunts in the plains, feizes old ones in their feats, digs out the rabbits in the warrens, finds out the nefts of partridges, quails, &c. feizes the mothers on the eggs, and deftroys a prodigious number of game. Dogs of all kinds fpontaneoufly hunt the fox. Though his odour be ftrong, they often prefer him to the ftag or the hare.

When purſued he runs to his hole; and it is not uncommon to ſend in terriers to detain him till the hunters remove the earth above, and either kill or ſeize him alive. The moſt certain method, however, of deſtroying a fox is to begin with ſhutting up the hole, to ſtation a man with a gun near the entrance, and then to ſearch about with the dogs. When they fall in with him, he immediately makes for his hole. But, when he comes up to it, he is met with a diſcharge from the gun. If the ſhot miſſes him, he flies off with full ſpeed, takes a wide circuit, and returns again to the hole, where he is fired upon a ſecond time; but, when he diſcovers that the entrance is ſhut, he darts away ſtraight forward, with the intention of never re-viſiting his former habitation. He is next purſued by the hounds, whom he ſeldom fails to fatigue; becauſe, with much cunning, he paſſes through the thickeſt part of the foreſt, or places of the moſt difficult acceſs, where the dogs are hardly able to follow him; and, when he takes to the plains, he runs ſtraight out, without either ſtopping or doubling. But the moſt effectual way of deſtroying foxes is to lay ſnares baited with live pigeons, fowls, &c. The fox is an exceedingly voracious animal. Beſide all kinds of fleſh and fiſhes, he devours, with equal avidity, eggs, milk, cheeſe, fruits, and particularly grapes. He is ſo extremely fond of honey, that he attacks the neſts of wild bees. They at firſt put him to flight by numberleſs ſtings; but he retires for the ſole purpoſe of rolling himſelf on the ground, and of cruſhing the bees. He returns to the charge ſo often, that he obliges them to abandon the hive, which he ſoon uncovers, and devours both the honey and the wax. Some time before the female brings forth, ſhe retires, and ſeldom leaves her hole, where ſhe prepares a bed for her young. When ſhe perceives that her retreat is diſcovered, and that her young have been diſturbed, ſhe carries them off, one by one, into a new habitation. The fox ſleeps in a round form, like the dog; but, when he only repoſes himſelf, he lies on his belly with his hind-legs extended. It is in this

this ſituation that he eyes the birds on the hedges and trees. The birds have ſuch an antipathy againſt him, that they no ſooner perceive him than they ſend forth ſhrill cries to advertiſe their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, ſometimes two or three hundred paces, often repeating the watch-cries. The Count de Buffon kept two young foxes, which, when at liberty, attacked the poultry; but, after they were chained, they never attempted to touch a ſingle fowl. A living hen was fixed near them for whole nights; and, though deſtitute of victuals for many hours, in ſpite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no diſturbance.

In Kamtſchatka, the animals called *gluttons* employ a ſingular ſtratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that ſpecies of moſs of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moſs. If the deer ſtops to eat the moſs, the glutton inſtantly darts down upon its back, and, after fixing himſelf firmly between the horns, tears out its eyes, which torments the animal to ſuch a degree, that, whether to put an end to its torments, or to get rid of its cruel enemy, it ſtrikes its head againſt the trees till it falls down dead. The glutton divides the fleſh of the deer into convenient portions, and conceals them in the earth to ſerve for future proviſions. The gluttons on the river Lena kill horſes in the ſame manner *.

There are ſeveral ſpecies of rats in Kamtſchatka. The moſt remarkable kind is called *tegulchitch* by the natives. Theſe rats make neat and ſpacious neſts underground. They are lined with turf, and divided

* Gazette Literaire, vol. 1. pag. 481.

divided into different apartments, in which the rats deposit stores of provisions for supporting them during the winter. It is worthy of remark, that the rats of this country never touch the provisions laid up for the winter, except when they cannot procure nourishment any where else. These rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtschatka for several years, and their retreat greatly alarms the inhabitants, which they consider as a presage of a rainy season, and of a bad year for hunting. The return of these animals is, of course, looked upon as a good omen. Whenever they appear, the happy news is soon spread over all parts of the country. They always take their departure in the spring, when they assemble in prodigious numbers, and traverse rivers, lakes, and even arms of the sea. After they have made a long voyage, they frequently lie motionless on the shore, as if they were dead. When they recover their strength they recommence their march. The inhabitants of Kamtschatka are very solicitous for the preservation of these animals. They never do the rats any injury, but give them every assistance when they lie weakened and extended on the ground. They generally return to Kamtschatka about the month of October; and they are sometimes met with in such prodigious numbers that travellers are obliged to stop two hours till the whole troop passes. The track of ground they travel in a single summer is not less wonderful than the regularity they observe in their march, and that instinctive impulse which enables them to foresee, with certainty, the changes of times and of seasons.

With regard to *Birds*, their artifices are not less numerous nor less surprising than those of quadrupeds. The eagle and hawk kinds are remarkable for the sharpness of their sight and the arts they employ in catching their prey. Their movements are rapid or slow, according to their intentions, and the situation of the animals they wish to devour. Rapacious birds uniformly endeavour to rise higher in the

the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counteract theſe artifices, Nature has endowed the ſmaller and more innocent ſpecies of birds with many arts of defence. When a hawk appears, the ſmall birds, if they find it convenient, conceal themſelves in hedges or bruſh-wood. When deprived of this opportunity, they often, in great numbers, ſeem to follow the hawk, and to expoſe themſelves unneceſſarily to danger, while, in fact, by their numbers, their perpetual changes of direction, and their uniform endeavours to riſe above him, they perplex the hawk to ſuch a degree, that he is unable to fix upon a ſingle object; and, after exerting all his art and addreſs, he is frequently obliged to relinquiſh the purſuit. When in the extremity of danger, and after employing every other artifice in vain, ſmall birds have been often known to fly to men for protection. This is a plain indication that theſe animals, though they in general avoid the human race, are by no means ſo much afraid of man as of rapacious birds.

The ravens often frequent the ſea-ſhores in queſt of food. When they find their inability to break the ſhells of muſcles, &c. to accompliſh this purpoſe they uſe a very ingenious ſtratagem: They carry a muſcle, or other ſhell-fiſh, high up in the air, and then daſh it down upon a rock, by which means the ſhell is broken, and they obtain the end they had in view.

The wood-pecker is furniſhed with a very long and voluble tongue. It feeds upon ants and other ſmall inſects. Nature has endowed this bird with a ſingular inſtinct. It knows how to procure food without ſeeing its prey. It attaches itſelf to the trunks or branches of decayed trees; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with inſects of different kinds. This operation is certainly inſtinctive; but the inftinct is affifted by the inftruction of the parents; for the young are no fooner able to fly, than the parents, by the force of example, teach them to refort to trees, and to infert their tongues indifcriminately into every hole or fiffure.

Of the oeconomy of *Fifhes*, as formerly remarked, our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general fcene of attack and defence, the arts of affault and of evafion muft, of courfe, be exceedingly various. For the prefervation of fome fpecies of fifhes, Nature has armed them with ftrong and fharp pikes. Others, as the perch-kind, are defended with ftrong bony rays in their fins. Others, as the univalve fhell-fifh, retire into their fhells upon the approach of danger. The bivalves and multivalves, when attacked, inftantly fhut their fhells, which, in general, is a fufficient protection to them. Some univalves, as the limpet-kind, attach themfelves fo firmly, by excluding the air, to rocks and ftones, that, unlefs quickly furprifed, no force inferior to that of breaking the fhell can remove them. The flying-fifh, when purfued, darts out of the water, and takes refuge in the air, in which it is for fome time fupported by the operation of its large and pliable fins. The torpedo is furnifhed with a remarkable apparatus for felf-prefervation: It repels every hoftile attempt by an electrical ftroke, which confounds and intimidates its enemies. Several fifhes, and particularly the falmon kind, when about to generate, leave the ocean, afcend the rivers, depofit their eggs in the fand, and, after making a proper *nidus* for their future progeny, return to the ocean from whence they came. Others, as the herring-kind, though they feldom go up rivers, affemble in myriads from all quarters, and approach the fhores, or afcend arms of the fea, for the purpofe of propagating the fpecies, and cherifhing their offspring. When that operation is performed, they leave the coafts and difperfe in the ocean, till the fame inftinctive impulfe forces them to obferve a fimilar

lar conduct next feafon. This migration of falmons, herrings, and many other fifhes, from the ocean to the rivers or fhores, is of infinite advantage to mankind. They fupply us occafionally, and in fome countries, as Great Britain, and particularly Scotland, with abundance of nourifhing and luxurious food; and, if our fifheries were once put upon a proper footing, they would foon conftitute one of the moft powerful incentives to induftry, and become a great and important fource of national ftrength and profperity.

The *infect* tribes, though comparatively diminutive, are not deficient in artifice and addrefs. With much art the fpider fpins his web. It ferves him the double purpofe of an habitation, and of a machine for catching his food. With incredible patience and perfeverance he lies in the center of his web for days, and fometimes for weeks, before an ill-fated fly happens to be entangled. One fpecies of fpider, which is fmall, of a blackifh colour, and frequents cottages or out-houfes, I have known to live during the whole winter months without almoft the poffibility of receiving any nourifhment; for, during that period, not a fly of any kind could be difcovered in the apartment. If they had been fixed in a torpid ftate, like fome other animals, the wonder of their furviving the want of food fo long would not have been fo great. But, in the fevereft weather, and through the whole courfe of the winter, they were perfectly active and lively. Neither did they feem to be in the leaft emaciated.

The *formico-leo*, or ant-lion, is a fmall infect, fomewhat refembling a wood-loufe, but larger. Its head is flat, and armed with two fine moveable crotchets or pincers. It has fix legs, and its body, which terminates in a point, is compofed of a number of membranous rings. In the fand, or in finely pulverifed earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambufh for its prey. As it always walks backward, it cannot purfue any infect.

To fupply this defect, it lays a fnare for them, and efpecially for the ant, which is its favourite food. It generally lies concealed under the fand in the bottom of its funnel or trap, and feldom exhibits more than the top of its head. In digging a funnel, the formica-leo begins with tracing a circular furrow in the fand, the circumference of which determines the fize of the funnel, which is often an inch deep. After the firft furrow is made, the animal traces a fecond, which is always concentric with the firft. It throws out the fand, as with a fhovel, from the fucceffive furrows or circles, by means of its fquare flat head and one of its fore-legs. It proceeds in this manner till it has completed its funnel, which it does with furprifing promptitude and addrefs. At the bottom of this artful fnare it lies concealed and immoveable. When an ant happens to make too near an approach to the margin of the funnel, the fides of which are very fteep, the fine fand gives way, and the unwary animal tumbles down to the bottom. The formica-leo inftantly kills the ant, buries it under the fand, and fucks out its vitals. It afterwards pufhes out the empty fkin, repairs the diforder introduced into its fnare, and again lies in ambufh for a frefh prey.

We formerly took fome notice of that fpecies of fpider which carries her eggs in a bag attached to her belly. A fpider of this kind was thrown into the funnel of a formica-leo. The latter inftantly feized the bag of eggs, and endeavoured to drag it under the fand. The fpider, from a ftrong love of offspring, allowed its own body to be carried along with the bag. But the flender filk by which it was fixed to the animal's belly broke, and a feparation took place. The fpider immediately feized the bag with her pincers, and exerted all her efforts to regain the object of her affections. But thefe efforts were ineffectual; for the formica-leo gradually funk the bag deeper and deeper in the fand. The fpider, however, rather than quit her hold, allowed herfelf to be buried alive. In a fhort time, the obferver ſerver removed the ſand, and took out the ſpider. She was perfectly unhurt; for the formica-leo had not made any attack upon her. But, ſo ſtrong was her attachment to her eggs, that, though frequently touched with a twig, ſhe would not relinquiſh the place which contained them *.

When arrived at its full growth, the formica-leo gives up the buſineſs of an enſnaring hunter. He deſerts his former habitation, and crawls about for ſome time on the ſurface of the earth. He at laſt retires under the ground, ſpins a round ſilken pod, and is ſoon transformed into a fly.

CHAP.

* Oeuvres de Bonnet, vol. 4. pag. 295. 8vo edit. Amſterdam 1769.

CHAPTER XVI.

Of the Society of Animals.

THE affociating principle, from which fo many advantages are derived, is not confined to the human fpecies, but extends, in fome inftances, to every clafs of animals.

It is remarked by Buffon, and fome other authors, that the ftate of Nature, which had long occupied the attention and refearches of philofophers, was rejected by them after the difcovery was made. In the eftimation of the authors alluded to, the favage ftate is the ftate of Nature. The firft natural condition of mankind is the union of a male and a female. Thefe produce a family, who, from neceffity, or, in other words, from parental and filial affection, continue together, and affift each other in procuring food and fhelter. This family, like moft families in eftablifhed civil focieties, feel their own weaknefs, and their inability to fupply their wants without more powerful refources than their feeble exertions. When this wandering and defencelefs family accidentally meet with another family in the fame condition, Nature, it is faid, teaches them to unite for mutual fupport and protection. The affociation of two families may be confidered as the firft formation of a tribe or nation. When

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a number of tribes happen to unite, they only become a larger or more numerous nation. A ſingle pair, it is true, if placed in a ſituation where plenty of food could be procured without much labour, might, in a ſucceſſion of ages, produce any indefinite number. This is preciſely the ſituation in which Moſes has placed our firſt parents. He has added another circumſtance highly favourable to a ſpeedy population. Inſtead of the preſent brevity of human life, he informs us, that men, in the firſt periods of the world, lived and propagated ſeveral hundred years.

In countries thinly peopled with ſavages, it is extremely probable, that ſocieties are formed by the gradual union of families and tribes. The increaſe of power ariſing from mutual aſſiſtance, and a thouſand other comfortable circumſtances, ſoon contribute to cement more firmly the aſſociated members. Some of the arts of life, beſide that of hunting, are occaſionally diſcovered either by accident or by the ingenuity of individuals. In this manner, gradual advances are made from the ſavage to the civilized condition of mankind. This is a very ſhort view of the origin of ſociety, which has been adopted by moſt authors both ancient and modern, though many of them have derived the aſſociating principle from very different, and even from oppoſite cauſes, which it is no part of our plan either to enumerate or refute. Some writers, as Ariſtotle, and a few moderns, implicit followers of his opinions, deny that man is naturally a gregarious or aſſociating animal. To render this notion conſiſtent with the actual and univerſal ſtate of the human race, theſe authors have had recourſe to puerile conceits, and to queſtionable facts, which it would be fruitleſs to relate. Other writers, poſſeſſed of greater judgment and diſcernment, and leſs warped with vanity and hypothetical phantoms, have derived the origin of ſociety from its real and only ſource, Nature herſelf.

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That the aſſociating principle is inſtinctive hardly requires a proof. An appeal to the feelings of any human being, and to the univerſal condition of mankind, is ſufficient. Theſe feelings, it may be ſaid, are acquired by education and habit. By theſe cauſes, it is true, our ſocial feelings are ſtrengthened and confirmed; but their origin is coeval with the exiſtence of the firſt human mind. Let any man attend to the eyes, the features, and the geſtures of a child upon the breaſt, when another child is preſented to it; both inſtantly, previous to the poſſibility of inſtruction or habit, exhibit the moſt evident expreſſions of joy. Their eyes ſparkle, their features and geſtures demonſtrate, in the moſt unequivocable manner, a mutual attachment, and a ſtrong deſire of approaching each other, not with a hoſtile intention, but with an ardent affection, which, in that pure and uncontaminated ſtate of our being, does honour to human nature. When farther advanced, children who are ſtrangers to each other, though their ſocial appetite is equally ſtrong, diſcover a mutual ſhyneſs of approach. This ſhyneſs or modeſty, however, is ſoon conquered by the more powerful inſtinct of aſſociation. They daily mingle and ſport together. Their natural affections, which, at that period, are ſtrong, and unbiaſſed by thoſe ſelfiſh and vicious motives which too often conceal and thwart the intentions of Nature, create warm friendſhips that frequently continue during their lives, and produce the moſt beneficial and cordial effects. When we thus ſee with our eyes, that the aſſociating principle appears at a period much more early than many of our other inſtincts, who will liſten to thoſe writers who chooſe to deny that man is, naturally, an aſſociating or gregarious animal?

With regard to the advantages we derive from aſſociation, a volume would not be ſufficient to enumerate them. Man, from the comparatively great number of inſtincts with which his mind is endowed, neceſſarily poſſeſſes a portion of the reaſoning faculty highly

ſuperior

ſuperior to that of any other animal. He alone enjoys the power of communicating and expreſſing his ideas by articulate and artificial language. This ineſtimable prerogative is, perhaps, one of the greateſt ſecondary bonds of ſociety, and the greateſt ſource of improvement to the human intellect. Without artificial language, though Nature has beſtowed on every animal a mode of expreſſing its wants and deſires, its pleaſures and pains, what an humiliating figure would the human ſpecies exhibit, even upon the ſuppoſition that they did aſſociate? But, when language and aſſociation are conjoined, the human intellect, in the progreſs of time, arrives at a high degree of perfection. Society gives riſe to virtue, honour, government, ſubordination, arts, ſcience, order, happineſs. All the individuals of a community conduct themſelves upon a regulated ſyſtem. Under the influence of eſtabliſhed laws, kings and magiſtrates, by the exerciſe of legal authority, encourage virtue, repreſs vice, and diffuſe, through the extent of their juriſdictions, the happy effects of their adminiſtration. In ſociety, as in a fertile climate, human talents germinate and are expanded; the mechanical and liberal arts flouriſh; poets, orators, hiſtorians, philoſophers, lawyers, phyſicians, and theologians, are produced. Theſe truths are pleaſant; and it were to be wiſhed that no evils accompanied them. But, through the whole extent of Nature, it ſhould appear, from our limited views, that good and evil, pleaſure and pain, are neceſſary and perpetual concomitants.

The advantages of ſociety are immenſe and invaluable. But the inconveniencies, hardſhips, injuſtice, oppreſſions, and cruelties, which too often originate from it are great and lamentable. Even under the mildeſt and beſt regulated governments, animoſities, jealouſies, avarice, fraud, and chicane, are unfortunately never removed from our obſervation. In abſolute monarchies, and particularly in deſpotic governments, the ſcenes of private and of general calamity and diſtreſs are often too dreadful to be deſcribed. Notwithſtanding all theſe diſadvantages, however, any government is preferable to anarchy; and the comforts, pleaſures, and improvements, we receive from aſſociating with each other, overbalance all the evils to which ſociety gives riſe.

From an attentive obſervation of the manners and oeconomy of animals, ſociety has been diſtinguiſhed into two kinds, which have been called *proper*, and *improper*. 1. *Proper Societies*, comprehend all thoſe animals who not only live together in numbers, but carry on certain operations which have a direct tendency to promote the welfare and happineſs of the community. 2. *Improper Societies*, include all thoſe animals who herd together, and love the company of each other, without carrying on any common operations.

1. *Proper Societies.*—It is almoſt needleſs to remark that man holds the firſt rank in animal aſſociations of this kind. If men did not aſſiſt each other, no operation of any magnitude, or which could ſhow any great ſuperiority of talents above thoſe of the brute creation, could poſſibly be effected. A ſingle family, or even a few families united, like other carnivorous animals, might hunt their prey, and procure a ſufficient quantity of food. They might, like the bear, lodge in the cavities of trees; they might occupy natural caves in the rocks; they might even build huts with branches of trees and with turf, and cement theſe groſs materials with clay. This loweſt and moſt abject view of human nature is not exaggerated. It were to be wiſhed that this grovelling condition of mankind were fictitious, and that, in many regions of the globe, it did not, at this moment, exiſt. Theſe operations of men, when only acquainted with the mere rudiments of ſociety, indicate parts little ſuperior to thoſe of the brutes. Man, even in his moſt uninformed ſtate, poſſeſſes the inſtincts, or the germs, of every ſpecies of knowledge and of genius.

But

But they muſt be cheriſhed, expanded, and brought gradually to perfection. It is by numerous and regularly eſtabliſhed ſocieties alone that ſuch glorious exhibitions of human intellect can be produced. What is the hut of a ſavage when compared to the palace of a prince? or what his canoe when compared to a firſt rate ſhip of war?

Next to the intelligence exhibited in human ſociety, that of the beavers is the moſt conſpicuous. Their operations in preparing, faſhioning, and tranſporting, the heavy materials for building their winter habitations, as formerly remarked *, are truly aſtoniſhing; and, when we read their hiſtory, we are apt to think that we are peruſing the hiſtory of man in a period of ſociety not inconſiderably advanced. It is only by the united ſtrength, and co-operation of numbers, that the beavers could be enabled to produce ſuch wonderful effects; for, in a ſolitary ſtate, as they at preſent appear in ſome northern parts of Europe, the beavers, like ſolitary ſavages, are timid and ſtupid animals. They neither aſſociate, nor attempt to conſtruct villages, but content themſelves with digging holes in the earth. Like men under the oppreſſion of deſpotic governments, the ſpirit of the European beavers is depreſſed, and their genius is extinguiſhed by terror, and by a perpetual and neceſſary attention to individual ſafety. The northern parts of Europe are now ſo populous, and the animals there are ſo perpetually hunted for the ſake of their furs, that they have no opportunity of aſſociating; of courſe, thoſe wonderful marks of their ſagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found. The ſociety of beavers is a ſociety of peace and of affection. They never quarrel or injure one another, but live together in different numbers, according to the dimenſions of particular cabins, in the moſt perfect harmony. The principle of their union is neither mo-

* See above, page 313, &c.

narchical nor defpotic. For the inhabitants of the different cabins, as well as thofe of the whole village, feem to acknowledge no chief or leader whatever. Their affociation prefents to our obfervation a model of a pure and perfect republic, the only bafis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wifh that it were poffible to eftablifh republics of this kind among mankind. But the difpofitions of men have little affinity to thofe of the beavers.

The hampfter, or German marmot, and fome other quadrupeds of this kind, live in fociety, and affift each other in digging and rendering commodious their fubterraneous habitations. The operations of the marmots have already been defcribed; and the nature of their fociety, as they continue during the winter in a torpid ftate, is either lefs known, or does not excite fo much admiration as that of the beavers.

Pairing birds, in fome meafure, may be confidered as forming proper focieties; becaufe, in general, the males and females mutually affift each other in building nefts and feeding their young. But this fociety, except in the eagle tribes, commonly continues no longer than their mutual offspring are fully able to provide for themfelves. None of the feathered tribes, as far as we know, unite in bodies, in order to carry on any operation common to the whole.

Neither do we learn from hiftory that fifhes ever affociate for the purpofe of executing any common operation. Many of them, as herrings, falmons, &c. affemble in multitudes at particular feafons of the year; but this affociation, to which they are impelled by inftinct, has no common object; for each individual is ftimulated to

act

aƈt in this manner by its own motives, and no general effeƈt is produced by mutual exertions.

In proper ſocieties, each individual not only attends to his own preſervation and welfare, but all the members co-operate in certain laborious offices which produce many common advantages that could not otherwiſe be procured. In ſome ſocieties, the general principle of aſſociation and of mutual labour is purely inſtinƈtive, though, in many caſes, individuals learn, by obſervation and experience, to modify or accommodate this general principle according to particular accidents or circumſtances; ſome examples of which have already been given in the chapter upon inſtinƈt.

The inſeƈt tribes furniſh many inſtances of proper ſocieties. The honey-bees not only labour in common with aſtoniſhing aſſiduity and art, but their whole attention and affeƈtions ſeem to centre in the perſon of the queen or ſovereign of the hive. She is the baſis of their aſſociation and of all their operations. When ſhe dies by any accident, the whole community are inſtantly in diſorder. All their labours ceaſe. No new cells are conſtruƈted. Neither honey nor wax are colleƈted. Nothing but perfeƈt anarchy prevails, till a new queen or female is obtained. The government or ſociety of bees is more of a monarchical than of a republican nature. The whole members of the ſtate ſeem to reſpeƈt and to be direƈted by a ſingle female. This faƈt affords a ſtrong inſtance of the force and wiſdom of Nature. The female alone is the mother of the whole hive, however numerous. Without her the ſpecies could not be continued. Nature, therefore, has endowed the reſt of the hive with a wonderful affeƈtion to their common parent. For the reception of her eggs Nature impels them to conſtruƈt cells, and to lay up ſtores of proviſions for winter ſubſiſtence. Theſe operations proceed from pure inſtinƈtive impulſes. But every inſtinƈt neceſſarily ſuppoſes a degree

of

of intellect, a fubftratum to be acted upon, otherwife no impulfe could be felt, and, of courfe, no action nor mark of intelligence could poffibly be produced.

That the intelligence, the government, and the fagacity of bees, have been frequently exaggerated, and as frequently mifunderftood, no real philofopher, or natural hiftorian, will pretend to deny. But the late ingenious Count de Buffon, through the whole of his great work, betrays the ftrongeft inclination to deny that brutes, even thofe which are efteemed to be the moft fagacious, as the dog, the elephant, &c. not to mention the inferior tribes, as birds, fifhes, and infects, are endowed with the fmalleft portion of mind or intellect, but that all their movements, their expreffions, their defires, their arts, are folely the refults of mechanical impulfes. The Count is peculiarly fevere in his declamations againft the fagacity of the honey-bees, and the celebrators of their oeconomy and manners. ‘ The genius of folitary bees,’ he remarks, ‘ is vaftly inferior to that of the gregarious fpecies; and ‘ the talents of thofe which affociate in fmall troops are lefs confpi-‘ cuous than of thofe that affemble in numerous bodies. Is not this ‘ alone fufficient to convince us, that the *feeming genius* of bees is ‘ nothing but a refult of *pure mechanifm*, a combination of move-‘ ments proportioned to numbers, an effect which appears to be com-‘ plicated, only becaufe it depends on thoufands of individuals? It ‘ muft, therefore, be admitted, that bees, taken feparately, have lefs ‘ genius than the dog, the monkey, and moft other animals: It will ‘ likewife be admitted, that they have lefs docility, lefs attachment, ‘ and lefs fentiment; and that they poffefs fewer qualities relative to ‘ thofe of the human fpecies. Hence we ought to acknowledge, ‘ that their apparent intelligence proceeds folely from the *multitude* ‘ *united*. This union, however, prefuppofes not intellectual powers; ‘ for they unite not from moral views: They find themfelves to-‘ gether without their confent. This fociety, therefore, is a phyfical

‘ affemblage

'assemblage ordained by Nature, and has no dependence on knowledge or reasoning. The mother bee produces at one time, and in 'the same place, ten thousand individuals, which, though they were 'much more stupid than I have supposed them, would be obliged, 'solely for the preservation of their existence, to arrange themselves 'into some order. As they all act against each other with equal 'forces, supposing their first movements to produce pain, they would 'soon learn to diminish this pain, or, in other words, to afford mutual assistance: They, of course, would exhibit an air of intelligence, and of concurring in the accomplishment of the same end. 'A superficial observer would instantly ascribe to them views and 'talents which they by no means possess: He would explain every 'action: Every operation would have its particular motive, and prodigies of reason would arise without number; for ten thousand individuals produced at one time, and obliged to live together, must 'all act in the very same manner; and, if endowed with feeling, 'they must acquire the same habits, assume that arrangement which 'is the least painful, or the most easy to themselves, labour in their 'hive, *return* after leaving it, &c. Hence the *origin* of the many 'wonderful talents ascribed to bees, such as their architecture, their 'geometry, their order, their foresight, their patriotism, and, in a 'word, their republic, the whole of which, as I have *proved*, has no 'existence but in the imagination of the observer *.'

That this mode of reasoning should have been seriously adopted by so great a literary character as that of the Count de Buffon, is truly astonishing. The substance of the argument is, that ten thousand bees, or other gregarious insects, when brought into existence at the same time, and in the same place, must necessarily, by the inconvenience or pain arising from mutual pressure, assume an arrangement;

* Translation, vol. 3. page 285.

ment, and conſtruct commodious and artful habitations for the whole community. I hate polemical argumentation; and philoſophical abſurdities are the moſt difficult to refute. If ten thouſand butterflies, or any other flies, whoſe inſtinctive or mental powers differed from thoſe of the bee, ſhould be brought forth at the ſame time, and in the ſame place, which might be eaſily effected by collecting their chryſalids, Would theſe animals, from the inconveniencies or pain they might ſuffer by being crouded together, aſſume a proper arrangement, and build habitations ſuited to their mutual comfort and preſervation? No. If not allowed to eſcape from their preſent ſituation, they would ſuffocate each other; and, if any of them were permitted to get out of their priſon, inſtead of returning, like the bees, they would avoid it with as much horror as a perſon who had made his eſcape from the Black Hole of Calcutta. No declamatory reaſoning, however ſpecious, will ever change the nature of truth. Without ſome portion of intellect, or what is ſynonimous, of mental powers, How ſhould the different kinds of bees in the ſame hive be induced to perform ſo many different operations? While ſome are buſily employed at home in the conſtruction of cells, others are equally induſtrious in the fields collecting materials for carrying on the work. They are no ſooner relieved from their load by their companions and fellow-labourers in the hive, than they again repair to the fields, and, with perſevering induſtry, fly from flower to flower till they have amaſſed another load of materials, which they immediately tranſport to the hive. In this laborious office they perſiſt for many hours every day when the weather permits. Will any man pretend to aſſert, that theſe, and many ſimilar operations performed by bees, are the reſults of mechanical impulſes *? Are bees, when collecting honey, and the farina of flowers, at great diſtances from

* For ſeveral curious operations of bees, which it will be difficult to reconcile with any principles of mechaniſm, the reader may conſult page 336, &c.

from the hive, compelled, by the mechanical preſſure of multitudes, to aſſume a certain arrangement, and all of them to act in the ſame manner? Can any animal be poſſeſſed of more liberty, or be more free from mechanical reſtraint, than a bee while roaming at large in the fields? Beſides, What ſhould force a bee, while wallowing in luxury, to return ſo repeatedly to the hive with no other view than to feed its companions, or to furniſh them with materials for their work? Here every idea of mechanical impulſe is utterly excluded. That bees, as well as other animals, are actuated by motives, or impulſes, it is willingly allowed. But theſe are not mechanical impulſes. They are the wiſe and irreſiſtible impulſes of Nature upon their minds. If bees did not aſſociate, and mutually aſſiſt one another in their various operations, the ſpecies would ſoon be annihilated. Not one of them, it is probable, would ſurvive the firſt winter. But Nature, ever ſolicitous for the preſervation of her productions, has endowed their minds with an aſſociating principle, and with inſtincts which ſtimulate them to perform all thoſe wonderful operations that are neceſſary for the exiſtence of individuals, and the continuation of the ſpecies.

What are called the *common* caterpillars afford an inſtance of proper aſſociation. About the middle of ſummer, a butterfly depoſits from three to four hundred eggs on the leaf of a tree, from each of which, in a few days, a young caterpillar proceeds. They are no ſooner hatched than they begin to form a common habitation. They ſpin ſilken threads, which they attach to one edge of the leaf, and extend them to the other. By this operation they make the two edges of the leaf approach each other, and form a cavity reſembling a hammock. In a ſhort time, the concave leaf is completely roofed with a covering of ſilk. Under this tent the animals live together in mutual friendſhip and harmony. When not diſpoſed to eat or to ſpin, they retire to their tent. It requires ſeveral of theſe habitations to contain the whole. According as the animals increafe in fize, the number of their tents is augmented. But thefe are only temporary and partial lodgements, conftructed for mutual conveniency, till the caterpillars are in a condition to build one more fpacious, and which will be fufficient to contain the whole. After gnawing one half of the fubftance of fuch leaves as happen to be near the end of fome twig or fmall branch, they begin their great work. In conftructing this new edifice or neft, the caterpillars encruft a confiderable part of the twig with white filk. In the fame manner, they cover two or three of fuch leaves as are neareft to the termination of the twig. They then fpin filken coverings of greater dimenfions, in which they inclofe the two or three leaves together with the twig. The neft is now fo fpacious that it is able to contain the whole community, every individual of which is employed in the common labour. Thefe nefts are too frequently feen, in autumn, upon the fruit-trees of our gardens. They are ftill more expofed to obfervation in winter, when the leaves, which formerly concealed many of them, are fallen. They confift of large bundles of white filk and withered leaves, without any regular or conftant form. Some of them are flat, and others roundifh; but none of them are deftitute of angles. By different plain coverings extended from the oppofite fides of the leaves and of the twig, the internal part of the neft is divided into a number of different apartments. To each of thefe apartments, which feem to be very irregular, there are paffages by which the caterpillars can either go out in queft of food, or retire in the evening, or during rainy weather. The filken coverings, by repeated layers, become at laft fo thick and ftrong, that they refift all the attacks of the wind, and all the injuries of the air, during eight or nine months. About the beginning of October, or when the froft firft commences, the whole community fhut themfelves up in the neft. During the winter they remain immoveable, and feemingly dead. But, when expofed to heat, they foon difcover fymptoms of life, and begin to creep. In this

this country, they ſeldom go out of the neſt till the middle or end of April. When they ſhut themſelves up for the winter, they are very ſmall; but, after they have fed for ſome days in ſpring upon the young and tender leaves, they find the neſt itſelf, and all the entrances to it, too ſmall for the increaſed ſize of their bodies. To remedy this inconveniency, theſe diſguſting reptiles know how to enlarge both the neſt and its paſſages by additional operations accommodated to their preſent ſtate. Into theſe new lodgings they retire when they want to repoſe, to ſcreen themſelves from the injuries of the weather, or to caſt their ſkins. In fine, after caſting their ſkins ſeveral times, the time of their diſperſion arrives. From the beginning to near the end of June, they lead a ſolitary life. Their ſocial diſpoſition is no longer felt. Each of them ſpins a pod of coarſe browniſh ſilk. In a few days they are changed into chryſalids; and, in eighteen or twenty days more, they are transformed into butterflies.

Caterpillars of another ſpecies, which Reaumur diſtinguiſhes by the appellation of the *proceſſionary caterpillar*, live in ſociety till their transformation into flies. Theſe caterpillars are of the hairy kind, and are of a reddiſh colour. They inhabit the oak, and feed upon its leaves. When very young, they have no fixed or general habitation. But, after they have acquired about one half of their natural ſize, they aſſemble together, and conſtruct a neſt ſufficient to accommodate the whole. The neſts of theſe caterpillars are attached to the trunks of the oak, and are ſituated ſometimes near the earth, and ſometimes ſeven or eight feet above its ſurface. They conſiſt of different ſtrata, or layers, of ſilk, which are ſpun by the united labour of the whole community. Their figure is neither ſtriking nor uniform. On the part of the oak to which they are fixed they form a protuberance ſimilar to thoſe knots which are ſeen upon trees. This protuberance ſometimes reſembles a ſegment of a circle, and ſometimes it is three or four times longer than it is broad. Some of theſe neſts are from eighteen to twenty inches long, and from five to ſix inches wide. About the middle of their convexity, they often riſe more than four inches above the ſurface of the tree. Between the trunk of the tree and the layers of ſilk a ſingle hole is left, to allow the animals to go out in queſt of food, and to retire into the neſt after they are ſatiated. Notwithſtanding the great bulk of theſe neſts, and though there are often three or four of them upon the ſame tree, and never elevated above the height of diſtinct viſion, they are not eaſily perceived; for the ſilk of which they are compoſed is cinereous, and reſembles, in colour, thoſe moſſes with which the trunk of the oak is generally covered.

The inhabitants of a neſt, which are numerous, march out, about the ſetting of the ſun, to forage, under the conduct of a chief or leader, all whoſe movements they uniformly follow. The order they obſerve is ſingular. The firſt rank conſiſts of ſingle animals, the ſecond of two, the third of three, the fourth of four, and ſometimes more. In this manner they proceed in queſt of food with all the regularity of diſciplined troops. The chief or leader has no marks of pre-eminence; for any individual that happens firſt to iſſue from the neſt, from that circumſtance alone, becomes the leader of an expedition. After making a full repaſt upon the neighbouring leaves, they return to the neſt in the ſame regular order; and this practice they continue during the whole period of their exiſtence in the caterpillar ſtate. It was from this ſtrange regularity of movement that Reaumur, with much propriety, denominated theſe animals *proceſſionary* caterpillars. When arrived at maturity, each individual ſpins a ſilken pod, is converted into a chryſalis, and afterwards aſſumes the form of a butterfly. This laſt tranſformation breaks all the bonds of their former aſſociation, and the

female

female flies depofit their eggs, which, when hatched, produce new colonies, who exhibit the fame oeconomy and manners.

There are feveral fpecies of caterpillars who are real republicans, and whofe difcipline, manners, and genius, are equally diverfified as thofe of the inhabitants of different nations and climates. Some, like particular favages, conftruct a kind of hammocks, in which they take their victuals, repofe, and fpend their lives till the period of their transformation. Others, like the Arabs and Tartars, conftruct and live in filken tents, and, after confuming the neighbouring herbage, they leave their former habitations, and encamp on frefh pafture. Under thefe tents they are not only protected from the injuries of the weather, but they repofe in them when fick, or in a ftate of inactivity. They go out of their tents at particular times in queft of food, and often to confiderable diftances; but they never lofe their way back. It is not by fight that they are directed with fo much certainty to their abodes. Nature has furnifhed them with another guide for regaining their habitations. We pave our ftreets with ftones; but the caterpillars cover all their roads with filken threads. Thefe threads make white tracks, which are often more than a fixth of an inch wide. It is by following thefe filken tracks, however complicated, that the caterpillars never mifs their nefts. If the road is broke by a man's finger drawn along it, or by any other accident, the caterpillars are greatly embarraffed. They ftop fuddenly at the interrupted fpace, and exhibit every mark of fear and of diffidence. Here the march ftops, till an individual, more bold or more impatient than his companions, traverfes the gap. In his paffage, he leaves behind him a thread of filk, which ferves as a bridge or conductor to the next that follows. By the progreffion of numbers, each of which fpins a thread, the breach is foon repaired. We cannot fuppofe that thefe ftupid animals cover their roads to prevent their wandering. But they never wander, becaufe their roads are

covered

covered with ſilk. In this, as well as in many other inſtances, Nature obliges animals to embrace the moſt effectual means of ſelf-preſervation, and even of conveniency, without their perceiving the utility of their own operations. The caterpillars, whoſe manners we have been deſcribing, ſpin almoſt continually, becauſe they are continually obliged to evacuate a ſilky matter, ſecreted from their food by veſſels deſtined for that purpoſe, and included in their inteſtines. In obeying this call of Nature, they effectually ſecure their retreat to their neſts, and perhaps their exiſtence. It may be ſaid, that caterpillars aſſociate for no other reaſon but becauſe they are all produced at the ſame time from eggs depoſited near each other. But many other ſpecies of caterpillars, who are brought to life in the very ſame circumſtances, never aſſociate or act in concert in the performance of any mutual labour. The ſilk-worms afford a familiar example. It is true, they ſpontaneouſly remain aſſembled in the ſame place, which is of great advantage to manufacture. But the individuals of other ſpecies diſperſe immediately after birth, and never re-unite. Spiders, when newly hatched, begin with ſpinning a web in common; but they ſoon terminate this aſſociation by devouring one another.

As caterpillars do not engender till they arrive at the butterfly ſtate, their aſſociations have no reſpect to the rearing or education of young. Self-preſervation and individual conveniency are the only bonds of their union. A perfect equality reigns among them, without any diſtinction of ſex, or even of ſize. Each takes his ſhare of the common labour; and the whole ſociety, which conſtitutes but one family, is the genuine iſſue of the ſame mother.

The aſſociation and oeconomy of the common ants merit ſome attention. With wonderful induſtry and activity they collect materials for the conſtruction of their neſt. They unite in numbers, and aſſiſt each other in excavating the earth, and in tranſporting to their habitation bits of ſtraw, ſmall pieces of wood, and other ſubſtances of a ſimilar kind, which they employ in lining and ſupporting their ſubterraneous galleries. The form of their neſt or hill is ſomewhat conical, and, of courſe, the water, when it rains, runs eaſily off, without penetrating their abode. Under this hill there are many galleries or paſſages which communicate with each other, and reſemble the ſtreets of a ſmall city.

The ants not only aſſociate for the purpoſe of conſtructing a common habitation, but for cheriſhing and protecting their offspring. Every perſon muſt have often obſerved, when part of a neſt is ſuddenly expoſed, their extreme ſolicitude for the preſervation of their chryſalids or nymphs, which often exceed the ſize of the animals themſelves. With amazing dexterity and quickneſs the ants tranſport their nymphs into the ſubterraneous galleries of the neſt, and place them beyond the reach of any common danger. The courage and fortitude with which they defend their young is no leſs aſtoniſhing. The body of an ant was cut through the middle, and, after ſuffering this cruel treatment, ſo ſtrong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great diſtances in ſearch of proviſions. Their roads, which are often winding and involved, all terminate in the neſt.

The wiſdom and foreſight of the ants have been celebrated from the remoteſt antiquity. It has been aſſerted and believed, for near three thouſand years, that they lay up magazines of proviſions for the winter, and that they even cut off the germ of the grain to prevent it from ſhooting. But the ancients were never famed for accurate reſearches into the nature and operations of inſects. Theſe ſuppoſed magazines could be of no uſe to the ants; for, like the

marmots

marmots and dormice, they ſleep during the winter. A very moderate degree of cold is ſufficient to render them torpid. In fact, it is now well known that they amaſs no magazines of proviſions. The grains which, with ſo much induſtry and labour, they carry to their neſt, are not intended to be food to the animals, but, like the bits of ſtraw and wood, are employed as materials in the conſtruction of their habitation.

2. *Improper Societies.*—Many animals are gregarious, though they unite not with a view to any joint operation, ſuch as conſtructing common habitations, or mutually and indiſcriminately nouriſhing and protecting the offspring produced by the whole ſociety. But, even among animals of this deſcription, there are motives or bonds of aſſociation, and, in many inſtances, they mutually aſſiſt and defend each other from hoſtile aſſaults.

The ox is a gregarious animal. When a herd of oxen are paſturing in a meadow, if a wolf makes his appearance, they inſtantly form themſelves in battle array, and preſent their united horns to the enemy. This warlike diſpoſition often intimidates the wolf, and obliges him to retire.

In winter, the hinds and young ſtags aſſociate, and form herds, which are always more numerous in proportion to the ſeverity of the weather. One bond of their ſociety ſeems to be the advantage of mutual warmth derived from each other's bodies. In ſpring they diſperſe, and the hinds conceal themſelves in the foreſts, where they bring forth their young. The young ſtags, however, continue together; they love to browſe in company; and neceſſity alone forces them to ſeparate.

The

The Count de Buffon reprefents fheep as ftupid creatures, which are incapable of defending themfelves againft the attacks of any rapacious animal. He maintains that the race muft long ago have been extinguifhed, if man had not taken them under his immediate protection. But Nature has furnifhed every fpecies of animated beings with weapons and arts of defence which are fufficient for individual prefervation as well as the continuation of the kind. Sheep are endowed with a ftrong affociating principle. When threatened with an attack, like foldiers, they form a line of battle, and boldly face the enemy. In a natural ftate, the rams conftitute one half of the flock. They join together and form the front. When prepared in this manner for repelling an affault, no lion or tiger can refift their united impetuofity and force.

A family of hogs, when in a ftate of natural liberty, never feparate till the young have acquired ftrength fufficient to repel the wolf. When a wolf threatens an attack, the whole family unite their forces, and bravely defend each other.

The wild dogs of Africa hunt in packs, and carry on a perpetual war againft other rapacious animals. The jackals of Afia and Africa likewife hunt in packs. But, though animals of this kind mutually affift each other in killing prey, individual advantage is the chief, if not the only bond of this temporary union.

Another kind of fociety is obfervable among domeftic animals. Horfes and oxen, when deprived of companions of their own fpecies, affociate, and difcover a vifible attachment. A dog and an ox, or a dog and a cow, when placed in certain circumftances, though the fpecies are remote, and even hoftile, acquire a ftrong affection for each other. The fame kind of affociation takes place between dogs and cats, between cats and birds, &c. If domeftic animals had a ſtrong averſion to one another, man could not derive ſo many advantages from them. Horſes, oxen, ſheep, &c. by browſing promiſcuouſly together, augment and meliorate the common paſture. By living under the ſame roof, and feeding in common, this aſſociating principle is ſtrengthened and modified by habit, which often commences immediately after birth. A ſingle horſe confined in an incloſure, diſcovers every mark of uneaſineſs. He becomes reſtleſs, neglects his food, and breaks through every fence in order to join his companions in a neighbouring field. Oxen and cows will not fatten in the fineſt paſture, if they are deprived of ſociety.

From the facts and remarks contained in this chapter, it ſeems to be evident, that the principle of aſſociation in man, as well as in many other animals, is purely inſtinctive; and that this principle may be ſtrengthened and modified by the numberleſs advantages derived from it, by imitation, by habit, and by many other circumſtances.

CHAPTER XVII.

Of the Docility of Animals.

OF all animals capable of culture, man is the moſt ductile. By inſtruction, imitation, and habit, his mind may be moulded into any form. It may be exalted by ſcience and art to a degree of knowledge, of which the vulgar and uninformed have not the moſt diſtant conception. The reverſe is melancholy. When the human mind is left to its own operations, and deprived of almoſt every opportunity of ſocial information, it ſinks ſo low, that it is nearly rivaled by the moſt ſagacious brutes. The natural ſuperiority of man over the other animals, as formerly remarked, is a neceſſary reſult of the great number of inſtincts with which his mind is endowed. Theſe inſtincts are gradually unfolded, and produce, after a mature age, reaſon, abſtraction, invention, ſcience. To confirm this truth, it would be fruitleſs to have recourſe to metaphyſical arguments, which generally miſlead and bewilder human reaſon. A diligent attention to the actual operations of Nature is ſufficient to convince any mind that is not warped and deceived by popular prejudice, the fetters of authorities, as they are called, whether ancient or modern, or by the vanity of ſupporting preconceived opinions and favourite theories. Let any man reflect on the progreſs of children from birth to manhood. At firſt, their inſtincts are limited to obſcure ſenſations, and to the performance of a few corporeal actions, to which they are prompted, or rather compelled, by certain ſtimulating impulſes unneceſſary to be mentioned. In a few months, their ſenſations are perceived to be more diſtinct, their bodily actions are better directed, new inſtincts are unfolded, and they aſſume a greater appearance of rationality and of mental capacity. When ſtill farther advanced, and after they have acquired ſome uſe of language, and ſome knowledge of natural objects, they begin to reaſon; but their reaſonings are feeble, and often prepoſterous. In this manner they uniformly proceed in improvement till they are actuated by the laſt inſtinct, at or near the age of puberty. After this period, they reaſon with ſome degree of perſpicuity and juſtneſs. But, though their whole inſtincts are now unfolded and in action, every power of their minds requires, previous to its utmoſt exertions, to be agitated and poliſhed by an examination of a thouſand natural and artificial objects, by the experience and obſervations of thoſe with whom they aſſociate, by public or private inſtruction, by ſtudying the writings of their predeceſſors and contemporaries, and by their own reflections, till they arrive at the age of thirty-five. Previous to that period, much learning may have been acquired, much genius may have been exerted; but, before that time of life, judgment, abſtraction, and the reaſoning faculty, are not fully matured. This progreſs is the genuine operation of Nature, and the gradual ſource of human ſagacity and mental powers. The ſame progreſs is to be obſerved in the powers of the body. It arrives, indeed, ſooner at perfection than the mind. But, if the progreſs of the mind greatly preceded that of the body, what a miſerable and aukward figure would human beings, at an early period of their exiſtence, exhibit? Active and vigorous minds, ſtimulated to command what the organs of their bodies were unable to obey, would produce peeviſhneſs, anger, regret, and every diſtreſſing paſſion.

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The bodies of men, though not ſo ductile as their minds, are capable, when properly managed by early culture, of wonderful exertions. Men, accuſtomed to live in poliſhed ſocieties, have little or no idea of the activity, the courage, the patience, and the perſevering induſtry of ſavages, when ſimply occupied in hunting wild animals for food to themſelves and their families. The hunger, the fatigue, the hardſhips, which they not only endure, but deſpiſe with fortitude, would amaze and terrify the imagination of any civilized European.

Beſide man, many other animals are capable of being inſtructed. The ape-kind, and eſpecially the larger ſpecies of them, imitate the actions of men without any inſtruction. This imitation they are enabled to perform with the greater exactneſs, on account of their ſtructure. The orang-outang, a native of the ſouthern regions of Africa and India, is as tall and as ſtrong as a man. He has no tail. His face is flat. His arms, hands, toes, and nails, are perfectly ſimilar to ours. He walks conſtantly on end; and the features of his viſage make a near approach to thoſe of the human countenance. He has a beard on his chin, and no more hair on his body than men have when in a ſtate of nature. He knows how to bear arms, to attack his enemies with ſtones, and to defend himſelf with a club. Of all the apes, the orang-outang, or *wild man*, as he is called by the Indians, has the greateſt reſemblance to man both in the ſtructure of his body and in his manners. There are two ſuppoſed ſpecies of orang-outang, a larger and a ſmaller. The latter has been ſeveral times brought to Europe, and accurate deſcriptions have been given both of his external and internal parts. But, with regard to the larger kind, who is ſaid to exceed the ordinary ſtature of man, we have nothing to rely on but the relations of travellers. Bontius, who was chief phyſician in Batavia, affirms expreſsly, that he ſaw, with admiration, ſeveral individuals of this ſpecies walking on their two feet. Among others, he remarked a female, who ſeemed to have a ſenſe of modeſty, who covered her face with her hands when men approached her with whom ſhe was unacquainted, who wept, groaned, and ſeemed to want nothing of humanity but the faculty of ſpeech *. Many other ſurpriſing actions performed by this animal are recorded by different voyagers, which it is unneceſſary to repeat, eſpecially as we have a ſufficient number of facts atteſted by unequivocal evidence. The Count de Buffon, with much probability, conſiders what are called the large and ſmall orang-outangs to be the ſame ſpecies of animals; for thoſe hitherto brought to Europe were very young, and had not acquired one half of their ſtature.

'The orang-outang,' ſays Buffon, 'which I ſaw, walked always 'on two feet, even when carrying things of conſiderable weight. 'His air was melancholy, his movements meaſured, his diſpoſitions 'gentle, and very different from thoſe of other apes. He had neither the impatience of the Barbary ape, the maliciouſneſs of the 'baboon, nor the extravagance of the monkeys. It may be alledged 'that he had the benefit of inſtruction; but the apes, which I ſhall 'compare with him, were educated in the ſame manner. Signs and 'words were alone ſufficient to make our orang-outang act: But 'the baboon required a cudgel, and the other apes a whip; for none 'of them would obey without blows. I have ſeen this animal preſent his hand to conduct the people who came to viſit him, and 'walk as gravely along with them as if he had formed a part of the 'company. I have ſeen him ſit down at table, unfold his towel, 'wipe his lips, uſe a ſpoon or a fork to carry the victuals to his 'mouth, pour his liquor into a glaſs, and make it touch that of the 'perſon who drank along with him. When invited to drink tea, 'he

* Jac. Bont. Hiſt. Nat. Ind. cap. 32.

'he brought a cup and a faucer, placed them on the table, put in 'fugar, poured out the tea, and allowed it to cool before he drank 'it. All thefe actions he performed without any other inftigation 'than the figns or verbal orders of his mafter, and often of his own 'accord. He did no injury to any perfon: He even approached 'company with circumfpection, and prefented himfelf as if he want-'ed to be careffed. He was very fond of dainties, which every 'body gave him: And, as his breaft was difeafed, and he was af-'flicted with a teazing cough, this quantity of fweatmeats un-'doubtedly contributed to fhorten his life. He lived one fummer 'in Paris, and died in London the following winter. He eat almoft 'every thing; but preferred ripe and dried fruits to all other kinds 'of food. He drank a little wine; but fpontaneoufly left it for 'milk, tea, or other mild liquors *.'

M. de la Broffe purchafed two orang-outangs from a Negro, whofe age exceeded not twelve months. 'Thefe animals,' he remarks, 'have the inftinct of fitting at table like men. They eat every 'kind of food without diftinction. They ufe a knife, a fork, or a 'fpoon, to cut or lay hold of what is put upon their plate. They 'drink wine and other liquors. We carried them aboard. At table, 'when they wanted any thing, they made themfelves be underftood 'by the cabin-boy: And, when the boy refufed to give them what 'they demanded, they fometimes became enraged, feized him by 'the arm, bit, and threw him down.—The male was feized with 'ficknefs in the road. He made himfelf be attended as a human 'being. He was even twice bled in the right arm: And, whenever 'he found himfelf afterwards in the fame condition, he held out 'his arm to be bled, as if he knew that he had formerly received 'benefit from that operation.'

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* Buffon, vol. 8. page 86. tranf.

We are informed by Francis Pyrard, ‘ that, in the province of ‘ Sierra-Leona, there is a ſpecies of animals called *baris*, (the orang-‘ outang), who are ſtrong and well limbed, and ſo induſtrious, ‘ that, when properly trained and fed, they work like ſervants; that ‘ they generally walk on the two hind-feet; that they pound any ‘ ſubſtances in a mortar; that they go to bring water from the river ‘ in ſmall pitchers, which they carry full on their heads. But, ‘ when they arrive at the door, if the pitchers are not ſoon taken ‘ off, they allow them to fall; and, when they perceive the pitcher ‘ overturned and broken, they weep and lament *.’ With regard to the education of theſe animals, the teſtimony of Schoutton correſponds with that of Pyrard. ‘ They are taken,’ ſays he, ‘ with ſnares, ‘ taught to walk on their hind-feet, and to uſe their fore-feet as ‘ hands in performing different operations, as rinſing glaſſes, carry-‘ ing drink round the company, turning a ſpit,’ &c. †. Guat informs us, that he ‘ ſaw at Java a very extraordinary ape. It was a ‘ female. She was very tall, and often walked erect on her hind-‘ feet. On theſe occaſions, ſhe concealed with her hands the parts ‘ which diſtinguiſh the ſex.—She made her bed very neatly every ‘ day, lay upon her ſide, and covered herſelf with the bed-clothes.—‘ When her head ached, ſhe bound it up with her handkerchief; ‘ and it was amuſing to ſee her thus hooded in bed. I could relate ‘ many other little articles which appeared to be extremely ſingular. ‘ But I admired them not ſo much as the multitude; becauſe, as I ‘ knew the deſign of bringing her to Europe to be exhibited as a ‘ ſhew, I was inclined to think that ſhe had been *taught* many of ‘ theſe monkey tricks, which the people conſidered as being natural ‘ to the animal. She died in our ſhip, about the latitude of the ‘ Cape

* Voyages de François Pyrard, tom. 2. pag. 331.

† Voyages de Schoutton aux Indes Orientales.

' Cape of Good Hope. The figure of this ape had a very great re-
' ſemblance to that of man *.'

We have now enumerated the principal facts regarding this extraordinary animal, which have been related by voyagers of credit, and by thoſe who have ſeen and examined him in Europe; and ſhall only remark, that, notwithſtanding the great ſimilarity of his ſtructure and organs to thoſe of the human ſpecies, his genius and talents ſeem to be very limited. The form of his body enables him to imitate every human action. But, though he has the organs of ſpeech, he is deſtitute of articulate language. If, however, he were domeſticated, and proper pains beſtowed for inſtructing him, he might unqueſtionably be taught to articulate. But, ſuppoſing this point to be obtained, if he remained incapable of reflection, if he was unable to comprehend the meaning of words, or to diſcover by his expreſſions a degree of intellect greatly ſuperior to that of the brute creation, which I imagine would be the caſe, he could never, as ſome authors have held forth, be exalted to the diſtinguiſhed rank of human beings.

Of all quadrupeds, of whoſe hiſtory and manners we have any proper knowledge, the elephant is moſt remarkable both for docility and underſtanding. Though his ſize is enormous, and his members rude and diſproportioned, which give him, at firſt ſight, the aſpect of dullneſs and ſtupidity, his genius is great, and his ſagacious manners, and his ſedate and collected deportment, are almoſt incredible. He is the largeſt and ſtrongeſt of all terreſtrial animals. Though naturally brave, his diſpoſitions are mild and peaceable. He is an aſſociating animal, and ſeldom appears alone in the foreſts. When in danger, or when they undertake a depredatory expedition into

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* Voyages de Fran. le Guat, tom. 2. pag. 96.

cultivated fields, the elephants aſſemble in troops. The oldeſt takes the lead; the next in ſeniority brings up the rear; and the young and the feeble occupy the center. In the foreſts and ſolitudes they move with leſs precaution; but never ſeparate ſo far aſunder as to render them incapable of affording each other mutual aſſiſtance when danger approaches. A troop of elephants conſtitutes a moſt formidable band. Wherever they march, the foreſt ſeems to fall before them. They bear down the branches upon which they feed; and, if they enter an incloſure, they ſoon deſtroy all the labours of the huſbandman. Their invaſions are the more tremendous, as there is hardly any means of repelling them; for, to attack a troop, when thus united, would require a little army. It is only when one or two elephants happen to linger behind the reſt, that the hunters dare exert their art and ingenuity in making an attack; for any attempt to diſturb the troop would certainly prove fatal to the aſſailants. When an inſult is offered, the elephants inſtantly move forward againſt the offender, toſs him in the air with their tuſks, and afterwards trample him to pieces under their feet, or rather pillars of fleſh and bone. Let not the character of this noble and majeſtic animal, however, be miſrepreſented. With force and dignity he reſents every affront; but, when not diſturbed by petulance or actual injury, he never ſhows an hoſtile intention either againſt man or any other animal. Elephants live entirely on vegetables, and have no thirſt for blood. Such is their ſocial and generous diſpoſition, that, when an individual chances to meet with a luxurious ſpot of paſture, he immediately calls to his companions, and invites them to partake of his good fortune.

The elephant poſſeſſes all the ſenſes in perfection: But, in the ſenſe of touching, he excells all the brute creation. His trunk is the chief inſtrument of this ſenſe. In an elephant of fourteen feet high, the trunk is about eight feet long, and five feet and an half in circumference

cumference at the baſe. It is a large fleſhy tube, divided through its whole extent by a ſeptum or partition. It is capable of motion in every direction. The animal can ſhorten or lengthen it at pleaſure. It anſwers every purpoſe of a hand; for it graſps large objects with great force, and its extremity can lay hold of a ſixpence, or even of a pin. The trunk of the elephant affords him the ſame means of addreſs as the ape. It ſerves the purpoſes of an arm and a hand. By this inſtrument, the elephant conveys large or ſmall bodies to his mouth, places them on his back, embraces them faſt, or throws them forcibly to a diſtance. In a ſtate of nature and perfect freedom, the diſpoſitions of the elephant are neither ſanguinary nor ferocious. They are gentle creatures, and never exert their ſtrength, or employ their weapons, but in defending themſelves or protecting their companions. Even when deprived of the inſtruction of men, they poſſeſs the ſagacity of the beaver, the addreſs of the ape, and the acuteneſs of the dog. To theſe mental talents are added the advantages of amazing bodily ſtrength, and the experience and knowledge he acquires by living at leaſt two centuries. With his trunk he tears up trees. By a puſh of his body he makes a breach in a wall. To this prodigious ſtrength he adds courage, prudence, and coolneſs of deportment. As he never makes an attack but when he receives an injury, he is univerſally beloved; and all animals reſpect, becauſe none have any reaſon to fear him. In all ages, men have entertained a veneration for this moſt magnificent and ſagacious of terreſtrial creatures. The ancients regarded him as a miracle of Nature, and he is, in reality, one of her greateſt efforts. But they have greatly exaggerated his faculties. Without heſitation, they have aſcribed to him high intellectual powers and moral virtues. Pliny, Ælian, Plutarch, and other authors of a more modern date, have beſtowed on the elephant not only rational manners, but an innate religion, a kind of daily adoration of the ſun and moon, the uſe of ablution before worſhip, a ſpirit of divination, piety toward heaven and their fellow creatures, whom they aſſiſt at the approach of death, and, after their deceaſe, bedew them with tears, and cover their bodies with earth.

When tamed and inſtructed by man, the elephant is ſoon rendered the mildeſt and moſt obedient of all domeſtic animals. He loves his keeper, careſſes him, and anticipates his commands. He learns to comprehend ſigns, and even to underſtand the expreſſion of ſounds. He diſtinguiſhes the tones of command, of anger, and of approbation, and regulates his actions by his perceptions. The voice of his maſter he never miſtakes. His orders are executed with alacrity, but without any degree of precipitation. His movements are always meaſured and ſedate, and his character ſeems to correſpond with the gravity of his maſs. To accommodate thoſe who mount him, he readily learns to bend his knees. With his trunk he ſalutes his friends, uſes it for raiſing burdens, and aſſiſts in loading himſelf. He loves to be clothed, and ſeems to be proud of gaudy trappings. In the ſouthern regions, he is employed in drawing waggons, ploughs, and chariots. 'I was eye-witneſs,' ſays P. Philippe, 'to the following facts. At Goa, there are always ſome elephants employed in the building of ſhips. I one day went to the ſide of the river, near which a large ſhip was building in the city of Goa, where there is a large area filled with beams for that purpoſe. Some men tie the ends of the heavieſt beams with a rope, which is handed to the elephant, who carries it to his mouth, and, after twiſting it round his trunk, draws it, without any conductor, to the place where the ſhip is building, though it had only once been pointed out to him. He ſometimes drew beams ſo large that more than twenty men would have been unable to move. But, what ſurpriſed me ſtill more, when other beams obſtructed the road, he elevated the ends of his own beams, that they might run eaſily over thoſe which lay in his way. Could the moſt enlightened man do

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'more *?' When at work, the elephant draws equally, and, if properly managed, never turns reſtive. The man who conducts the animal generally rides on his neck, and employs a hooked iron road, or a bodkin, with which he pricks the head or ſides of the ears, in order to puſh the creature forward, or to make him turn. But words are commonly ſufficient. The attachment and affection of the elephant are ſometimes ſo ſtrong and durable that he has been known to die of grief, when, in an unguarded paroxyſm of rage, he had killed his guide.

Before the invention of gun-powder, elephants were employed in war by the African and Aſiatic nations. 'From time immemo-'rial,' ſays Schouten, 'the Kings of Ceylon, of Pegu, and of Ara-'can, have uſed elephants in war. Naked ſabres were tied to their 'trunks, and on their backs were fixed ſmall wooden caſtles, which 'contained five or ſix men armed with javelins, and other wea-'pons †.' The Greeks and Romans, however, ſoon became acquainted with the nature of theſe monſtrous warriors. They opened their ranks to let the animals paſs, and directed all their weapons, not againſt the elephants, but their conductors. Since fire has now become the element of war, and the chief inſtrument of deſtruction, elephants, who are terrified both at the flame and the noiſe, would be more dangerous than uſeful in our modern battles. The Indian Kings, however, ſtill arm elephants in their wars. In Cochin, and other parts of Malabar, all the warriors who fight not on foot are mounted on elephants ‡. The ſame practice obtains in Tonquin, Siam, and Pegu. In theſe countries, the kings and nobles at public feſtivals are always preceded and followed by numerous trains of elephants,

* Voyage d'Orient. pag. 367.

† Voyage de Schouten, pag. 32.

‡ Thevenot, tom. 3. pag. 261.

elephants, pompoufly adorned with pieces of fhining metal, and clothed with rich garments. Their tufks are ornamented with rings of gold and filver; their ears and cheeks are painted with various colours; they are crowned with garlands; and a number of fmall bells are fixed to different parts of their bodies. They delight in gaudy attire; for they are chearful and careffing in proportion to the number and fplendour of their ornaments. The Afiatics, who were very anciently civilized, perceiving the fagacity and docility of the elephant, educated him in a fyftematic manner, and modified his difpofitions according to their own manners, and the ufeful labours in which his ftrength and dexterity could be employed.

A domeftic elephant performs more labour than could be accomplifhed by fix horfes; but he requires much care and a great deal of food. He is fubject to be over-heated, and muft be led to the water twice or thrice a-day. He eafily learns to bathe himfelf. With his trunk he fucks up large quantities of water, carries it to his mouth, drinks part of it, and, by elevating his trunk, makes the remainder run over every part of his body. To give fome idea of the labour he performs, and the docility of his difpofitions, it is worthy of remark, that, in India, all the bales, facks, and tuns, tranfported from one place to another, are carried by elephants. They carry burdens on their bodies, their necks, their tufks, and even in their mouths, by giving them the end of a rope, which they hold faft with their teeth. Uniting fagacity with ftrength, they never break or injure any thing committed to their charge. From the margins of the rivers, they put weighty bundles into boats without wetting them, lay them down gently, and arrange them where they ought to be placed. When the goods are difpofed as their mafters direct, they examine with their trunks whether the articles are properly ftowed; and, if a cafk or tun rolls, they go fpontaneoufly in queft of ftones to prop and render it firm.

In the elephant, the ſenſe of ſmelling is acute, and he is paſſionately fond of odoriferous flowers, which he collects one by one, forms them into a noſegay, and, after gratifying his noſe, conveys them to his mouth.

In India, the domeſtic elephants, to whom the uſe of water is as neceſſary as that of air, are allowed every poſſible conveniency for bathing themſelves. The animal goes into a river till the water reaches his belly. He then lies down on one ſide, fills his trunk ſeveral times, and dexterouſly throws the water on ſuch parts as happen to be uncovered. The maſter, after cleaning and currying one ſide, deſires the animal to turn to the other, which command he obeys with the greateſt alacrity; and, when both ſides have been properly cleaned, he comes out of the river, and ſtands ſome time on the bank to dry himſelf. The elephant, though his maſs be enormous, is an excellent ſwimmer; and, of courſe, he is of great uſe in the paſſage of rivers. When employed on occaſions of this kind, he is often loaded with two pieces of cannon which admit three or four pound balls, beſide great quantities of baggage and ſeveral men fixed to his ears and his tail. When thus heavily loaded, he ſpontaneouſly enters the river and ſwims over with his trunk elevated in the air for the benefit of reſpiration. He is fond of wine and ardent ſpirits. By ſhowing him a veſſel filled with any of theſe liquors, and promiſing him it as the reward of his labours, he is induced to exert the greateſt efforts, and to perform the moſt painful taſks. The elephant, as we are informed by M. de Buſſy, quoted by the Count de Buffon, is employed in dragging artillery over mountains, and, on theſe occaſions, his ſagacity and docility are conſpicuous. Horſes or oxen, when yoked to a cannon, make all their exertions to pull it up a declivity. But the elephant puſhes the breach forward with his front, and, at each effort, ſupports the carriage with his knee, which he places againſt the wheel. He ſeems

to

to underftand what his *cornack*, or conductor, fays to him. When his conductor wants him to perform any painful labour, he explains the nature of the operation, and gives the reafons which fhould induce him to obey. If the elephant fhows a reluctance to the tafk, the cornack promifes to give him wine, arrack, or any other article that he is fond of, and then the animal exerts his utmoft efforts. But to break any promife made to him is extremely dangerous. Many cornacks have fallen victims to indifcretions of this kind. 'At 'Dehan,' fays M. de Buffy, 'an elephant, from revenge, killed his 'cornack. The man's wife, who beheld the dreadful fcene, took 'her two children, and threw them at the feet of the enraged ani'mal, faying, *Since you have flain my hufband, take my life alfo, as* '*well as that of my children.* The elephant inftantly ftopped, re'lented, and, as if ftung with remorfe, took the eldeft boy in its 'trunk, placed him on its neck, adopted him for its cornack, and 'would never allow any other perfon to mount it.'

From the members of the Royal Academy of Sciences, we learn fome curious facts with regard to the manners of the Verfailles elephant. This elephant, they remark, feemed to know when it was mocked, and remembered the affront till it had an opportunity of revenge. A man deceived it, by pretending to throw fome food into its mouth. The animal gave him fuch a blow with its trunk as knocked him down, and broke two of his ribs. A painter wanted to draw the animal in an unufual attitude, with its trunk elevated, and its mouth open. The painter's fervant, to make it remain in this pofition, threw fruits into its mouth, but generally made only a faint of throwing them. This conduct enraged the elephant; and, as if it knew that the painter was the caufe of this teazing impertinence, inftead of attacking the fervant, it eyed the mafter, and fquirted at him from its trunk fuch a quantity of water as fpoiled the paper on which he was drawing. This elephant commonly made lefs ufe of its ftrength than its addrefs. It loofed, with great eafe and coolnefs, the buckle of a large double leathern ftrap, with which its leg was fixed; and, as the fervants had wrapped the buckle round with a fmall cord, and tied many knots upon it, the creature, with much deliberation, loofed the whole, without breaking either the ftrap or the cord.

It is remarked by le P. Vincent Marie, that the elephant, when in a domeftic ftate, is highly efteemed for his gentlenefs, docility, and friendfhip to his governour. When deftined to the immediate fervice of princes, he is fenfible of his good fortune, and maintains a gravity of demeanour correfponding to the dignity of his fituation. But if, on the contrary, lefs honourable labours are affigned to him, he grows melancholy, frets, and evidently difcovers that he is humbled and depreffed. He is fond of children, careffes them, and appears to difcern the innocence of their manners. The Dutch voyagers relate *, that, by giving elephants what is agreeable to them, they are foon rendered perfectly tame and fubmiffive. They are fo fagacious, that they may be faid to be deftitute of the ufe of language only. They are proud and ambitious; and they are fo grateful for good ufage, that, as a mark of refpect, they bow their heads in paffing houfes where they have been hofpitably received. They allow themfelves to be led and commanded by a child; but they love to be praifed and careffed. When a wild elephant is taken, the hunters tie his feet, and one of them accofts and falutes him, makes apologies for binding him, protefts that no injury is intended, tells him, that, in his former condition, he frequently wanted food, but that, henceforward, he fhall be well treated, and that every promife fhall be performed to him. This foothing harangue is no fooner

* Voyage de la Compagnie des Indes de Hollande, tom. 1. pag. 413.

finiſhed than the elephant placidly follows the hunter *. From this fact, however, we muſt not conclude that the elephant underſtands language, but that, like the dog, he has a ſtrong diſcerning faculty. He diſtinguiſhes eſteem from contempt, friendſhip from hatred, and many other emotions which are expreſſed by human geſtures and features. For this reaſon, the elephant is more eaſily tamed by mildneſs than by blows.

‘ I have frequently remarked,’ ſays Edward Terry †, ‘that the elephant performs many actions which ſeem to proceed more from ‘ reaſon than from inſtinct. He does every thing that his maſter ‘ commands. If he wants to terrify any perſon, he runs upon him ‘ with every appearance of fury, and, when he comes near, ſtops ‘ ſhort, without doing the perſon the ſmalleſt injury. When the ‘ maſter chooſes to affront any man, he tells the elephant, who immediately collects water and mud with his trunk, and ſquirts it ‘ upon the object pointed out to him. The Mogul keeps ſome elephants who ſerve as executioners to criminals condemned to death. ‘ When the conductor orders one of theſe animals to deſpatch the ‘ poor criminals quickly, he tears them to pieces in a moment with ‘ his feet: But, if deſired to torment them ſlowly, he breaks their ‘ bones one after another, and makes them ſuffer a puniſhment as ‘ cruel as that of the wheel.’

Next to the elephant, the dog ſeems to be the moſt docile quadruped. A wild dog is a paſſionate, ferocious, and ſanguinary animal. But, after he is reduced to a domeſtic ſtate, theſe hoſtile diſpoſitions are ſuppreſſed, and they are ſucceeded by a warm attachment, and a perpetual deſire of pleaſing. The perceptions and natural talents of

* Voyage d'Orient. du P. Phillippe, pag. 366.

† Terry's Voyage to the Eaſt Indies, pag. 15.

of the dog are acute. When theſe are aided by inſtruction, the ſagacity he diſcovers, and the actions he is taught to perform, often excite our wonder. Thoſe animals which man has taken under his immediate protection are taught to perform artificial actions, or have their natural inſtincts improved, by three modes of inſtruction, puniſhment, reward, and imitation. More ductile in his nature than moſt other animals, the dog not only receives inſtruction with rapidity, but accommodates his behaviour and deportment to the manners and habits of thoſe who command him. He aſſumes the very tone of the family in which he reſides. Eager, at all times, to pleaſe his maſter, or his friends, he furiouſly repels beggars; becauſe he probably, from their dreſs, conceives them to be either thieves, or competitors for food.

Though every dog, as well as every man, is naturally a hunter, the dexterity of both is highly improved by experience and inſtruction. The varieties of dogs, by frequent intermixtures with thoſe of different climates, and perhaps with foxes and wolves, are ſo great, and their inſtincts are ſo much diverſified, that, even though they produce with each other, we ſhould be apt to regard them as different ſpecies. What a difference between the natural diſpoſitions of the ſhepherd's dog, the ſpaniel, and the grey-hound? The ſhepherd's dog, independently of all inſtruction, ſeems to be endowed by Nature with an innate attachment to the preſervation of ſheep and cattle. His docility is likewiſe ſo great, that he not only learns to underſtand the language and commands of the ſhepherd, and obeys them with faithfulneſs and alacrity, but, when at diſtances beyond the reach of his maſter's voice, he often ſtops, looks back, and recogniſes the approbation or diſapprobation of the ſhepherd by the mere waving of his hand. He reigns at the head of a flock, and is better heard than the voice of his maſter. His vigilance and activity produce order, diſcipline, and ſafety. Sheep and cattle are peculiarly ſubjected to his management, whom he prudently conducts and protects, and never employs force againſt them, except for the preſervation of peace and good order. But, when the flock committed to his charge is attacked by the fox, the wolf, or other rapacious animals, he makes a full diſplay of his courage and ſagacity. In ſituations of this kind, both his natural and acquired talents are exerted. Three ſhepherds dogs are ſaid to be a match for a bear, and four for a lion.

Every perſon knows the docility and ſagacity of ſuch dogs as are employed in conducting blind mendicants. Johannes Faber, as quoted by Mr Ray, informs us, that he knew a blind beggar who was led through the ſtreets of Rome by a middle ſized dog. This dog, beſide leading his maſter in ſuch a manner as to protect him from all danger, learned to diſtinguiſh not only the ſtreets, but the houſes where his maſter was accuſtomed to receive alms twice or thrice a-week. Whenever the animal came to any of theſe ſtreets, with which he was well acquainted, he would not leave it till a call had been made at every houſe where his maſter was uſually ſucceſſful in his petitions. When the beggar began to aſk alms, the dog, being wearied, lay down to reſt; but the maſter was no ſooner ſerved or refuſed, than the dog roſe ſpontaneouſly, and, without either order or ſign, proceeded to the other houſes where the beggar generally received ſome gratuity. I obſerved, ſays he, not without pleaſure and ſurpriſe, that, when a halfpenny was thrown from a window, ſuch was the ſagacity and attention of this dog, that he went about in queſt of it, lifted it from the ground with his mouth, and put it into his maſter's hat. Even when bread was thrown down, the animal would not taſte it, unleſs he received a portion of it from the hand of his maſter. Without any other inſtruction than imitation, a maſtiff, when accidentally ſhut out from a houſe which his maſter frequented, uniformly rung the bell for admittance. Dogs

can

can be taught to go to market with money, to repair to a known butcher, and to carry home the meat in ſafety. They can be taught to dance to muſic, and to ſearch for and find any thing that is loſt *.

There is a dog at preſent belonging to a grocer in Edinburgh, who has for ſome time amuſed and aſtoniſhed the people in the neighbourhood. A man who goes through the ſtreets ringing a bell and ſelling penny pies, happened one day to treat this dog with a pye. The next time he heard the pyeman's bell, he ran to him with impetuoſity, ſeized him by the coat, and would not ſuffer him to paſs. The pyeman, who underſtood what the animal wanted, ſhowed him a penny, and pointed to his maſter, who ſtood in the ſtreet-door, and ſaw what was going on. The dog immediately ſupplicated his maſter by many humble geſtures and looks. The maſter put a penny into the dog's mouth, which he inſtantly delivered to the pyeman, and received his pye. This traffick between the pyeman and the grocer's dog has been daily practiſed for months paſt, and ſtill continues.

Dogs, horſes, and even hogs, by rewards and puniſhments, and, I am afraid, often by cruelty, may be taught to perform actions, as we have frequently ſeen in public exhibitions, which are truly aſtoniſhing. But of theſe we muſt not enter into any detail.

With regard to the horſe, the gentleneſs of his diſpoſitions, and the docility of his temper, are ſo well and ſo univerſally known, that it is unneceſſary to dwell long upon the ſubject. To give ſome idea of what inſtruction horſes receive when in a domeſtic ſtate, we ſhall mention ſome traits of their form and manners when under no

* For theſe, and many other inſtances of the ſagacity and docility of the dog, the reader may conſult *Synopſis Quadrupedum a Joanne Raio, p. 6. &c.*

no reſtraints. In South America the horſes have multiplied prodigiouſly, and, in that thinly inhabited country, live in perfect freedom. They fly from the preſence of man. They wander about in troops, and devour, in immenſe meadows, the productions of a perpetual ſpring. Wild horſes are ſtronger, lighter, and more nervous, than the generality of thoſe which are kept in a domeſtic ſtate. They are by no means ferocious. Though ſuperior in ſtrength to moſt animals, they never make an attack. When aſſaulted, however, they either diſdain the enemy, or ſtrike him dead with their heels. They aſſociate in troops from mutual attachment, and neither make war with other animals nor among themſelves. As their appetites are moderate, and they have few objects to excite envy or diſcord, they live in perpetual peace. Their manners are gentle, and their tempers ſocial. Their force and ardour are rendered conſpicuous only by marks of emulation. They are anxious to be foremoſt in the courſe, to brave danger in croſſing a river, or in leaping a ditch or precipice; and, it is ſaid, that thoſe horſes which are moſt adventurous and expert in theſe natural exerciſes, are, when domeſticated, the moſt generous, mild, and tractable.

Wild horſes are taken notice of by ſeveral of the ancients. Herodotus mentions white wild horſes on the banks of the Hypanis in Scythia. He likewiſe tells us, that, in the northern part of Thrace, beyond the Danube, there were wild horſes covered all over with hair five inches in length. The wild horſes in America are the offſpring of domeſtic horſes originally tranſported thither from Europe by the Spaniards. The author of the hiſtory of the Buccaneers * informs us, that troops of horſes, ſometimes conſiſting of 500, are frequently met with in the iſland of St Domingo; that, when they ſee a man, they all ſtop; and that one of their number approaches to

* L'Hiſt. des Avanteur. Flibuſtiers, tom. 1. pag. 110.

to a certain diftance, blows through his noftrils, takes flight, and is inftantly followed by the whole troop. He defcribes them as having grofs heads and limbs, and long necks and ears. The inhabitants tame them with eafe, and then train them to labour. In order to take them, gins of ropes are laid in the places where they are known to frequent. When caught by the neck, they foon ftrangle themfelves, unlefs fome perfon arrive in time to difentangle them. They are tied to trees by the body and limbs, and are left in that fituation two days without victuals or drink. This treatment is generally fufficient to render them more tractable, and they foon become as gentle as if they had never been wild. Even when any of thefe horfes, by accident, regain their liberty, they never refume their favage ftate, but know their mafters, and allow themfelves to be approached and retaken.

From thefe, and fimilar facts, it may be concluded, that the difpofitions of horfes are gentle, and that they are naturally difpofed to affociate with man. After they are tamed they never forfake the abodes of men. On the contrary, they are anxious to return to the ftable. The fweets of habit feem to fupply all they have loft by flavery. When fatigued, the manfion of repofe is full of comfort. They fmell it at confiderable diftances, can diftinguifh it in the midft of populous cities, and feem uniformly to prefer bondage to liberty. By fome attention and addrefs colts are firft rendered tractable. When that point is gained, by different modes of management, the docility of the animal is improved, and they foon learn to perform with alacrity the various labours affigned to them. The domeftication of the horfe is perhaps the nobleft acquifition from the animal world which has ever been made by the genius, the art, and the induftry of man. He is taught to partake of the dangers and fatigues of war, and feems to enjoy the glory of victory. He encounters death with ardour and with magnanimity. He delights in the tumult

mult of arms, and attacks the enemy with reſolution and alacrity. It is not in perils and conflicts alone that the horſe co-operates with the diſpoſitions of his maſter. He even ſeems to participate of human pleaſures and amuſements. He delights in the chace and the tournament, and his eyes ſparkle with emulation in the courſe. Though bold and intrepid, however, he does not allow himſelf to be hurried on by a furious ardour. On proper occaſions, he repreſſes his movements, and knows how to check the natural fire of his temper. He not only yields to the hand, but ſeems to conſult the inclination of his rider. Always obedient to the impreſſions he receives, he flies or ſtops, and regulates his motions ſolely by the will of his maſter.

Mr Ray, who wrote about the end of laſt century, informs us, that he had ſeen a horſe who danced to muſic, who, at the command of his maſter, affected to be lame, who ſimulated death, lay motionleſs with his limbs extended, and allowed himſelf to be dragged about, till ſome words were pronounced, when he inſtantly ſprung up on his feet *. Facts of this kind would ſcarcely receive credit, if every perſon were not now acquainted with the wonderful docility of the horſes educated by Aſtley, and other public exhibitors of horſemanſhip. In exhibitions of this kind, the docility and prompt obedience of the animals deſerve more admiration than the dexterous feats of the men.

Animals of the ox-kind, in a domeſtic ſtate, are dull and phlegmatic. Their ſenſibility and talents ſeem to be very limited. But we ſhould not pronounce raſhly concerning the genius and powers of animals in a country where their education is totally neglected. In all the ſouthern provinces of Africa and Aſia, there are many wild biſons, or

* Raii Synopſis Animalium Quadrupedum, pag. 10.

or bunched oxen, which are taken when young and tamed. They are ſoon taught to ſubmit, without reſiſtance, to all kinds of domeſtic labour. They become ſo tractable, that they are managed with as much eaſe as our horſes. The voice of their maſter is alone ſufficient to make them obey, and to direct their courſe. They are ſhod, curried, carreſſed, and ſupplied abundantly with the beſt food. When managed in this manner, theſe animals appear to be different creatures from our oxen. The oxen of the Hottentots are favourite domeſtics, companions in amuſements, aſſiſtants in all laborious exerciſes, and participate the habitation, the bed, and the table of their maſters. As their nature is improved by the gentleneſs of their education, by the kind treatment they receive, and the perpetual attention beſtowed on them, they acquire ſenſibility and intelligence, and perform actions which one would not expect from them. The Hottentots train their oxen to war. In all their armies there are conſiderable troops of theſe oxen, which are eaſily governed, and are let looſe by the chief when a proper opportunity occurs. They inſtantly dart with impetuoſity upon the enemy. They ſtrike with their horns, kick, overturn, and trample under their feet every thing that oppoſes their fury. They run ferociouſly into the ranks, which they ſoon put into the utmoſt diſorder, and thus pave the way for an eaſy victory to their maſters *. Theſe oxen are likewiſe inſtructed to guard the flocks, which they conduct with dexterity, and defend them from the attacks of ſtrangers, and of rapacious animals. They are taught to diſtinguiſh friends from enemies, to underſtand ſignals, and to obey the commands of their maſter. When paſturing, at the ſmalleſt ſignal from the keeper, they bring back and collect the wandering animals. They attack all ſtrangers with fury, which renders them a great ſecurity againſt robbers. Theſe *brackeleys*, as they are called, know every inhabitant of the kraal, and diſcover

* Voyage de Cap, par Kolbe, tom. 1. pag. 160.

the ſame marks of reſpect for all the men, women, and children, as a dog does for thoſe who live in his maſter's houſe. Theſe people may, therefore, approach their cattle with the greateſt ſafety. But, if a ſtranger, and particularly an European, ſhould uſe the ſame freedom, without being accompanied with one of the Hottentots, his life would be in imminent danger *.

Notwithſtanding the many ſurpriſing actions which different quadrupeds may be taught to perform, none of them, though their organs are much more perfect than thoſe of birds, have ever been able to pronounce articulate ſounds. But many birds, without much inſtruction, learn to pronounce words, and even ſentences. In parrots, the diſtinguiſhing accuracy of their ear, the acuteneſs of their attention, and their ſtrong inſtinctive propenſity to imitate ſounds of every kind, have juſtly procured them univerſal admiration. When in a ſtate of domeſtication, the parrot learns to pronounce the common ſtreet-calls, beſide many words and phraſes occaſionally employed by the family in which he reſides. Though the limitation of his mental powers does not permit him to learn any extent of language, or the proper uſe and meaning of words, he not unfrequently diſcovers the aſſociation between the object and the ſound. A woman every morning paſſed the window, where a parrot's cage was fixed, calling ſalt. The parrot ſoon learned to imitate the call. But, before any ſound could be heard, he no ſooner caſt his eye upon the woman than he uttered her uſual call. In this, and many other ſimilar caſes, the objects and the ſounds are evidently connected in the mind of the animal. How far theſe aſſociations might be carried by a patient and perſevering education, it is difficult to determine. In this manner, however, parrots might be taught a conſiderable vocabulary of ſubſtantive nouns, or the proper names of

* Voyage de Cap, par Kolbe, pag. 307.

of common objects. But his intellect, it is more than probable, would never reach the ufe of the verb, and other parts of fpeech.

Befide parrots, jays, &c. who learn to pronounce articulate founds, there is another race of birds whofe docility deferves to be mentioned. Singing birds, thofe lively and fpirited little animals, attempt not to articulate. But their mufical ears are as delicate and difcerning as their voices are melodious and delightful. The vivacity, the extent of voice, and the imitative powers of thefe beautiful creatures, have at all times excited the attention and conciliated the affections of mankind. When domefticated, thefe birds, befide their natural notes, foon acquire the faculty of finging confiderable parts of artificial tunes. Thefe imitations are effects of natural inftinct. But, in exhibitions, I have feen linnets fimulate death, and remain perfectly tranquil and unmoved, when fmall cannons were fired, within an inch of their bodies, from a wooden fort. Thefe little creatures have even been taught to lay hold of a match and fire the cannons themfelves.

The docility and fagacity of animals have always been confidered as wonderful. But this wonder is partly the effect of inattention; for, though man is unqueftionably the chief of the animal creation, the other animals, according to the number of inftincts, or, which amounts to the fame thing, according to the mental powers with which Nature has endowed them, comparatively approach to or recede from the fagacity and genius of the human fpecies. The whole is a graduated fcale of intelligence. A philofopher fhould, therefore, contemplate and admire the whole, but fhould never be furprifed at any partial exhibitions of the general fcene of intellect and animation.

We ſhall conclude this ſubject with a few remarks concerning the changes produced in animals by DOMESTICATION.

Climate and food are the chief cauſes which produce changes in the magnitude, figure, colour, and conſtitution, of wild animals. But, beſide theſe cauſes, there are others which have an influence upon animals when reduced to a domeſtic or unnatural ſtate. When at perfect liberty, animals ſeem to have ſelected thoſe particular zones or regions of the globe which are moſt conſonant to the nature and conſtitution of each particular tribe. There they ſpontaneouſly remain, and never, like man, diſperſe themſelves over the whole ſurface of the earth. But, when obliged by man, or by any great revolution of Nature, to abandon their native ſoil, they undergo changes ſo great, that, to recogniſe and diſtinguiſh them, recourſe muſt be had to the moſt accurate examination. If we add to climate and food, thoſe natural cauſes of alteration in free animals, the empire of man over ſuch of them as he has reduced to ſervitude, the degree to which tyranny degrades and disfigures Nature will appear to be greatly augmented. The mouflon, the ſtock from which our domeſtic ſheep have derived their origin, is comparatively a large animal. He is as fleet as a ſtag, armed with horns and ſtrong hoofs, and covered with coarſe hair. With theſe natural advantages, he dreads neither the inclemency of the ſky, nor the voracity of the wolf. By the ſwiftneſs of his courſe, he not only eſcapes from his enemies, but he is enabled to reſiſt them by the ſtrength of his body and the ſolidity of his arms. How different is this animal from our domeſtic ſheep, who are timid, weak, and unable to defend themſelves? Without the protection of man, the whole race would ſoon be extirpated by rapacious animals and by winter-ſtorms. In the warmeſt climates of Africa and of Aſia, the mouflon, who is the common parent of the ſheep, appears to be leſs degenerated than in any other region. Though reduced to a domeſtic ſtate, he has preſerved preferved his ftature and his hair; but the fize of his horns is diminifhed. The fheep of Barbary, Egypt, Arabia, Perfia, &c. have undergone greater changes; and, in proportion as they approach toward either pole, they diminifh in fize, in ftrength, in fwiftnefs, and in courage. In relation to man, they are improved in fome articles, and vitiated in others. Their coarfe hair is converted into fine wool. But, with regard to Nature, improvement and degeneration amount to the fame thing; for both imply an alteration of the original conftitution.

The ox is more influenced by nourifhment than any other domeftic animal. In countries where the pafture is luxuriant, the oxen acquire a prodigious fize. To the oxen of Æthiopia and fome provinces of Afia, the ancients gave the appellation of *Bull-Elephants*, becaufe, in thefe regions, they approach to the magnitude of the elephant. This effect is chiefly produced by the abundance of rich and fucculent herbage. The Highlands of Scotland, and indeed every high and northern country, afford ftriking examples of the influence of food upon the magnitude of cattle. The oxen, as well as the horfes, in the more northern parts of Scotland, are extremely diminutive; but, when tranfported to richer pafture, their fize is augmented, and the qualities of their flefh are improved. The climate has likewife a confiderable influence on the nature of the ox. In the northern regions of both continents, he is covered with long foft hair. He has likewife a large bunch on his fhoulders; and this deformity is common to the oxen of Afia, Africa, and America. Thofe of Europe have no bunch. The European oxen, however, feem to be the primitive race, to which the bunched kind afcend, by intermixture, in the fecond or third generation. The difference in their fize is remarkably great. The fmall zebu, or bunched ox of Arabia, is not one tenth part of the magnitude of the Æthiopian bull-elephant.

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The influence of food upon the dog-kind feems not to be great. In all his variations and degradations, he appears to follow the differences of climate. In the warmeft climates, he is naked; in the northern regions, he is covered with a coarfe thick hair; and he is adorned with a fine filky robe in Spain and Syria, where the mild temperature of the air converts the hair of moft quadrupeds into a kind of filk. Befide thefe external variations produced by climate, the dog undergoes other changes, which proceed from his fituation, his captivity, and the nature of the intercourfe he holds with man. His fize is augmented or diminifhed by obliging the fmaller kinds to unite together, and by obferving the fame conduct with the larger individuals. The fhortening of the tail and ears proceeds alfo from the hand of man. Dogs who have had their ears and tails cut for a few generations, tranfmit thefe defects, in a certain degree, to their defcendants. Pendulous ears, the moft certain mark of domeftic fervitude and of fear, are almoft univerfal. Of many races of dogs, a few only have retained the primitive ftate of their ears. Erect ears are now confined to the wolf-dog, the fhepherd's dog, and the dog of the North.

The colour of animals is greatly variegated by domeftication. The dog, the ox, the fheep, the goat, the horfe, have affumed all kinds of colours, and even mixtures of colours, in the fame individuals. The hog has changed from black to white; and white, without the intermixture of fpots, is generally accompanied with effential imperfections. Men who are remarkably fair, and whofe hair is white, have generally a defect in their hearing, and, at the fame time, weak and red eyes. Quadrupeds which are entirely white have likewife red eyes and a dullnefs of hearing. The variations from the original colour are moft remarkable in our domeftic fowls. In a brood of chickens, though the eggs be laid by the fame hen, and though the female be impregnated by the ſame male, not one of them has the ſame colours with another.

Domeſtication not only changes the external appearances of animals, but alters or modifies their natural diſpoſitions. The dog, for example, when in a ſtate of liberty, is a rapacious quadruped, and hunts and devours the weaker ſpecies: But, after he has ſubmitted to the dominion of man, he relinquiſhes his natural ferocity, and is converted into a mean, ſervile, patient, and paraſitical ſlave.

CHAPTER XVIII.

Of the Characters of Animals.

ON this ſubject it never was intended to paint the characters of every ſpecies, even of the larger animals. The reader will eaſily recollect, that, in many parts of this work, much has already been ſaid with regard to the tempers, diſpoſitions, and manners, of a great number of animals. Theſe we ſhall not repeat, but proceed to ſome general remarks.

On every animal Nature has imprinted a certain *character*, which is indelibly fixed, and diſtinguiſhes the ſpecies. This character we diſcover by the actions, the air, the countenance, the movements, and the whole external appearance. The courage of the lion, the ferocity of the tiger, the voracioufneſs of the wolf, the pride of the courſer, the dullneſs and indolence of the aſs, the cunning and addreſs of the fox, the affection and docility of the dog, the ſubtlety and ſelfiſhneſs of the cat, the mildneſs of the ſheep, the timidity of the hare, the vivacity of the ſquirrel, are proper examples. Theſe characters, when under the influence of domeſtication, may be modified by education, of which rewards and puniſhments are the chief inſtruments employed. But the original character, impreſſed by the hand of Nature, is never fully obliterated. Thoſe animals which ſeem to have been deſtined by Nature to live in perpetual ſlavery under the dominion of man, have the mildeſt and moſt gentle diſpoſitions. It is pleaſant, but, at the ſame time, ſomewhat contemptible, to ſee a troop of oxen guided by the whip of a child.

In the human ſpecies, the variety of tempers, affections, averſions, and ſtudies, is indiſpenſibly neceſſary for ſupporting the ſocial ſtate, and carrying on the general buſineſs of life. Some minds are formed for ſtudy and deep reſearch, and others for action, courage, and the exertion of bodily powers. The ſame variety in the diſpoſitions and manners of the different tribes of animals is equally neceſſary for peopling the earth, and for ſupplying the reciprocal exigencies of its inhabitants.

Beſide the general ſpecific characters of animals, individual characters, eſpecially among the human race, are ſtrongly marked, and greatly variegated. In every government, and particularly in commercial ſtates, human characters, independently of the original bias, or genius, ſtamped by Nature on individual minds, are often ſo diſguiſed by a thouſand artifices, that it requires not only time, but frequent intereſting ſcenes, before a man can diſcover the real character even of an intimate companion. Many men aſſociate together in the moſt harmonious manner, and ſhow every ſymptom of friendſhip and attachment; but, when any of them happens to be diſtreſſed, and to require aid, all this apparent friendſhip inſtantly vaniſhes, the aſpect of the countenance, inſtead of exhibiting ſympathy and cordiality, is converted into a cold reſerve, and the unfortunate former companion is firſt ſhunned, and then deſerted. This picture of human nature, we are ſorry to remark, is too general; but, thank Heaven, it is not univerſal; for there always were, and ſtill are, men of noble and generous minds, who willingly ſacrifice part of their own intereſt to that of their friends.

With regard to the characters of quadrupeds, beſide the ſpecific diſpoſitions which diſtinguiſh the different kinds, each individual poſſeſſes a peculiar character by which it may be diſcriminated from any other. Theſe individual characters may be diſcovered not only by the aſpect, but by the actions of animals. Some dogs, even of the ſame race, are ſurly, churliſh, and revengeful. Others are gay, frolickſome, and friendly. The countenances of men, which always indicate ſome part of their original and genuine character, are as various as their numbers. Though leſs ſubject to general obſervation, Nature has marked the countenances of every animal, even down to the inſect tribes, with ſome characteriſtic ſtrokes, which enable them to diſtinguiſh one another, and even to contract particular attachments. To us, the ſmall birds, ſuch as ſparrows and linnets, appear to be ſo perfectly ſimilar, that, though we had an opportunity of ſeeing great numbers of them collected in one place, it would require much time and attention to be enabled to make individual diſtinctions. After they have brought up their young, they aſſociate promiſcuouſly in flocks; but, when the genial ſpring arrives, a different ſcene is exhibited. The flocks diſappear. Each male has ſelected, courted, and retired with a female to build a neſt, to hatch eggs, and to nouriſh and ſupport their young. If Nature had not ſtamped upon every individual a peculiar mark, it would be impoſſible that the immenſe multitudes who pair, or join in matrimony, ſhould be capable of diſtinguiſhing and adhering faithfully to one another. A ſhepherd, who has been long accuſtomed to ſuperintend a numerous flock, knows, by the countenances, and other natural or accidental marks, every individual. I knew a ſhepherd, who not only diſtinguiſhed every individual of above two hundred ſheep, but gave to each a particular name.

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The characters of quadrupeds, and even of fome birds, are indicated by obfcure refemblances between the lineaments of their faces, and thofe of men of different features and difpofitions. Some men, in the general expreffion of their countenances, refemble goats, others fheep, others oxen, others fwine, others lions, others dogs, others foxes, others owls, others hawks. Even in particular races of the fame fpecies, fimilarities of this kind may be traced. I know fome men who refemble terriers, others greyhounds, others fpaniels, others the fhepherd's dog, others the lap-dog, &c. Some of thefe refemblances may be regarded as fanciful, and perhaps they frequently are. But, in general, when the refemblance to a particular animal is ftrongly marked in a human countenance, the difpofitions of the man have a ftriking affinity to thofe of the animal. Men who refemble the fox are uniformly cunning and deceitful. Thofe who refemble the ox are dull, ftupid, and phlegmatic. Thofe who refemble the lion are bold, open, generous, and witty. Thofe who refemble the cat are circumfpect, defigning, and avaricious. Thofe who refemble the greyhound are vigilant, active, and fmart. Thofe who refemble the lap-dog are vain, prefumptuous, petulant, and lafcivious. Thofe who refemble the fow are difguftful both in their appearance and in their difpofitions. Thofe who refemble a crofsmade horfe are cruel, unfeeling, and highly felfifh. Thofe who refemble the fpaniel, of whom the examples are numerous, are fawning, mean, and parafitical. Thofe who refemble the fheep are dull, timid, and inoffenfive. Thofe who refemble the goat are fanciful, obftinate, and libidinous. Thofe who refemble a fine horfe are intrepid, generous, tractable, and good humoured. Thofe who refemble a hawk are quick, defultory, and ingenious. Thofe who refemble the owl are dark, defigning, and treacherous. Thofe who refemble the bee are active, ignorant, and induftrious. It is needlefs to multiply examples. Every man's recollection and obfervation will furnifh him with numberlefs coincidences between the fimila-

 rities

rities in ſtructure and features to particular animals, and the form, diſpoſitions, and manners, of the men who poſſeſs them.

Compariſons have been inſtituted, and analogies traced, between the ſtructure, aſpect, and diſpoſitions, of ſome quadrupeds and thoſe of certain birds, which ſhow a uniformity in the general plan of Nature. Among birds, as well as quadrupeds, ſome ſpecies are carnivorous, and others feed upon fruits, grain, and various kinds of herbage. The eagle, which is a noble and a generous bird, repreſents the lion. The vulture, which is cruel and inſatiable, repreſents the tiger. The kite, the buzzard, and the raven, who live chiefly on offals and carrion, repreſent the hyaena, the wolf, and the jackal. The falcon, the ſparrow-hawk, and other birds employed in hunting, repreſent the dog, the fox, the lynx, &c. The owl, who ſearches for her prey in the night, repreſents the cat. The heron and the cormorant, who feed upon fiſhes, repreſent the beaver and the otter. Peacocks, hens, and all other birds which have a crop, or craw, repreſent oxen, ſheep, goats, and other ruminating animals.

CHAP.

CHAPTER XIX.

Of the Principle of Imitation.

IMITATION neceffarily implies fome degree of intelligence. All animals, particularly thofe of the more perfect kinds, are endowed with the principle of imitation. The confequence is obvious, that all animals poffefs a certain portion of intellectual power. In man, the principle of imitation appears at a very early period of his exiftence. In the more advanced ftages of life, this principle is fo interwoven with other motives of acting and thinking, that it is difficult to diftinguifh it as a feparate inftinct, and equally difficult to conquer the habits and prejudices to which it has given rife. The lefs a man has cultivated his rational faculties, the more powerful is the principle of imitation over his actions and his habits of thinking. Moft women, of courfe, are more influenced by the behaviour, the fafhions, and the opinions of thofe with whom they affociate than men. From this almoft irrefiftible inftinct, we fhould learn the extreme danger of frequenting the company of the diffolute and unprincipled; for bad habits are foon acquired, but very difficult to conquer. It is a comfortable circumftance, however, that if men, efpecially when young, are fortunate enough to fall in with the fociety of the virtuous and intelligent, the principle of imitation, fo benevolent is Nature, acts with redoubled force. If we attend to our own

feelings,

feelings, we muſt acknowledge, that, in the acquiſition of bad habits, there is an evident force upon our natural inclinations, but that, in virtuous aſſociations, the mind acquieſces with pleaſure, and feels no reſtraint in complying with the examples it perceives nor in acquiring the correſpondent habits We are prone to evil; but, when not corrupted by improper imitations, Nature has made us much more prone to good.

Artificial language, which we learn entirely by imitation, diſtinguiſhes us, more than any other circumſtance, from the brute creation. The proper uſe of it likewiſe forms the chief difference between one man and another; for, by language, one man diſcovers a ſuperiority of knowledge and of genius, while others expreſs by it nothing but borrowed or confuſed ideas. In an idiot, or in a parrot, it marks only the moſt abject degree of ſtupidity. It ſhows the incapacity of either to produce a regular chain of thinking, though both of them be endowed with organs capable of expreſſing what paſſes within their minds. Men whoſe ſenſes are delicate, and whoſe minds are eaſily affected, make the beſt actors, and the beſt mimics. Children, accordingly, are extremely alert in imitating the actions, the geſtures, and the manners, of thoſe with whom they aſſociate. They are dexterous in perceiving ridiculous figures and repreſentations, which they imitate with eaſe and propriety. Hence we perceive, in the education of children, the infinite importance of regulating the principle of imitation.

The education of the inferior animals, though ſhort, is always ſucceſsful. By imitation, they ſoon acquire all the knowledge poſſeſſed by their parents. They not only derive experience from their own feelings, but, by imitation, they learn and employ the experience of others. Young animals model their actions entirely upon thoſe of the old. They ſee their ſeniors approach or fly when they

perceive

perceive particular objects, hear particular founds, or fmell certain odours. At firft, they approach or fly without any other determining principle but that of imitation. Afterwards, they approach or fly fpontaneoufly, becaufe they have then acquired the habit of approaching or flying, whenever they feel the fame or fimilar fenfations. Many inftincts, as terror upon hearing particular founds, the appearance of natural enemies, the felection of food, &c. feem to be partly the effects of imitation. It is remarked by Ulloa, that, in the year 1743, the dogs in Juan Fernandes had loft the faculty of barking. When affociated with other dogs, it was with great difficulty that they again learned, by imitation, to bark. The caufe of thefe dogs lofing the expreffion of their ufual language in a domeftic ftate, it is not eafy to inveftigate. Perhaps, by the aid of experience, and their own fagacity, they difcovered that barking warned their prey to efcape from danger. The jackals, however, who are confidered as belonging to the dog-kind, not only hunt in packs, but, during the chace, make a loud and a hideous noife. Mr White, in his Natural Hiftory of Selborne, a work which contains much information, and difcovers a good and benevolent heart in the author, informs us, that he had an opportunity of feeing two dogs, a male and a female, which had been brought from Canton in China. Thefe dogs, which, in China, are fattened for eating, are about the fize of an ordinary fpaniel, and are of a pale yellow colour. 'When taken 'out into a field,' he remarks, 'the bitch fhowed fome difpofition 'for hunting, and dwelt on the fcent of a covey of partridges till 'fhe fprung them, giving her tongue all the time. The dogs in 'South America are dumb; but thefe bark much in a fhort thick 'manner, like foxes; and have a furly favage demeanour, like their 'anceftors, which are not domefticated, but bred up in ftıes, where 'they are fed for the table with rice-meal, and other farinaceous 'food. Thefe dogs, having been taken on board as foon as weaned, 'could not have learned much from their dam; yet they did not 'relifh

'relifh flefh when they came to England. In the iflands of the Pa-
'cific Ocean, the dogs are bred upon vegetables, and would not eat
'flefh when offered them by our circumnavigators.'

From facts of this kind, of which a great number might be mentioned, the following obfervations naturally arife. Thefe Chinefe dogs, though defcended, probably for many generations, from a race of anceftors who never had the leaft experience or education in hunting, preferved their original inftinct of fcenting and purfuing game. The dog is a grofsly carnivorous animal; for he prefers carrion to any other kind of nourifhment; yet the Chinefe dogs difcovered no particular relifh for the flefh of animals. Thus it appears, that, by habits, acquired, not by the individual, but by a train of anceftors, both the tafte and the conftitution of animals may be greatly altered. From the fame facts, however, it is equally evident, that Nature can never be entirely conquered. The moment the Chinefe dogs firft faw a field, they both fcented and hunted game. Imitation and habit feem to have greater effects upon the mode of living, feeding, and the corporeal fabrick, than upon the original inftincts of the mind. Thefe dogs, even when they came to England after a long voyage, had not acquired the habit of greedily devouring, like other dogs, either frefh meat or carrion; but, on the firft opportunity afforded to them, they difcovered an inclination to hunt.

CHAP.

CHAPTER XX.

Of the Migration of Animals.

THE Hon. Daines Barrington, in his *Eſſay on the Periodical Appearing and Diſappearing of certain Birds*, *at different times of the year* *, has, by many ingenious arguments, as well as curious facts, rendered it extremely probable, that no birds, however ſtrong and ſwift in their flight, can poſſibly fly over ſuch large tracts of the ocean as has been commonly ſuppoſed. He admits partial migrations or *flittings*, as he calls them, though he does not attempt to aſcertain the diſtances of theſe flittings. With regard to the ſwallows, of which there are ſeveral ſpecies in Britain, ſome naturaliſts, of whom the Hon. Daines Barrington is one, are inclined to think that they do not leave this iſland at the end of autumn, but that they lie in a torpid ſtate till the beginning of ſummer in the banks of rivers, the hollows of decayed trees, the receſſes of old buildings, the holes of ſand-banks, and in ſimilar ſituations. That ſwallows, in the winter months, have ſometimes, though very rarely, been found in a torpid ſtate, is unqueſtionably true. Neither is the inference, that, if any of them can ſurvive the winter in that ſtate, the whole of them may ſubſiſt, during the cold ſeaſon, in the ſame con-

* Phil. Tranſact. vol. 62. pag. 265, &c.

dition, in the ſmalleſt degree unnatural. Still, however, the numbers of ſwallows which appear in this iſland, as well as in all parts of Europe, during the ſummer months, are ſo very conſiderable, that, if the great body of them did not migrate to ſome other climate, they ſhould be much more frequently found in a torpid ſtate. On the contrary, when a few of them are diſcovered in that ſtate, it is regarded as a wonder even by the country people, who have the greateſt opportunities of ſtumbling upon facts of this kind. When, accordingly, a few ſwallows or martins are found torpid in winter, and have been revived by a gentle heat, the fact, and few ſuch facts there are, is carefully recorded as ſingular in all the periodical publications of Europe.

Mr Pennant informs us, from undoubted authority, that ſome quails, and other birds which are generally ſuppoſed to leave this iſland in winter, retire to the ſea-coaſts, and pick up their food among the ſea-weeds *.

'Quails,' Mr Pennant remarks, 'are birds of paſſage; ſome entirely quitting our iſland, others ſhifting their quarters. A gentleman, to whom this work lies under great obligations, has aſſured us, that theſe birds migrate out of the neighbouring inland counties, into the hundreds of Eſſex in October, and continue there all the winter: If froſt or ſnow drive them out of the ſtubble-fields and marſhes, they retreat to the ſea-ſide, ſhelter themſelves among the weeds, and live upon what they can pick up from the algae, &c. between high and low water mark. Our friend remarks, that the time of their appearance in Eſſex coincides with that of their leaving the inland counties †.'

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* Brit. Zool. Vol. 1. pag. 210. 2d edit. 8vo.

† Pennant, ibid.

A quail, it muſt be allowed, ſeems to be very much unqualified for a long migration; for its tail is ſhort, the bird never riſes more than twenty or thirty feet from the ground, and it ſeldom flies above three hundred yards at a time. Belon, however, an author of great ſagacity and credit, tells us, that, in his paſſage from Rhodes to Alexandria, many quails, flying from north to ſouth, were taken in his ſhip. From this circumſtance, he remarks, ' I am perſuaded ' that they ſhift places; for formerly, when I ſailed out of the Iſle ' of Zant to Morea, or Negropont, in the ſpring, I obſerved quails ' flying the contrary way, at which time, alſo, a great many were ' taken in our ſhip.' This traverſe they might be enabled to accompliſh by paſſing from one iſland to another in the Mediterranean.

Inſtances of ſwallows and ſome other birds alighting on the maſts and cordage of veſſels, at conſiderable diſtances from any ſhore, are not ſo numerous as might be expected. Neither have they been often obſerved flying over ſeas in great flocks. Mr Peter Collinſon, in a letter printed in the Philoſophical Tranſactions, ſays, ' that Sir ' Charles Wager had frequently informed him, that, in one of his ' voyages home in the ſpring, as he came into ſoundings in our ' channel, a great flock of ſwallows almoſt covered his rigging; ' that they were nearly ſpent and famiſhed, and were only feathers ' and bones; but, being recruited by a night's reſt, they took their ' flight in the morning.'

M. Adanſon, in his voyage, informs us, that, about fifty leagues from the coaſt of Senegal, four ſwallows ſettled upon the ſhip, on the ſixth day of October; that theſe birds were taken; and that he knew them to be the true ſwallow of Europe, which he conjectures were then returning to the coaſt of Africa. The Hon. Daines Barrington, with more probability, ſuppoſes that theſe ſwallows, inſtead of being on their paſſage from Europe, were only flitting from the Cape de Verde iſlands to the continent of Africa, a much ſhorter flight, but to which they ſeemed to be unequal, as they were obliged, from fatigue, to light upon the ſhip, and fall into the hands of the ſailors.

Swallows, Mr Kalm remarks, appear in the Jerſies about the beginning of April. They are, on their firſt arrival, wet, becauſe they have juſt emerged from the ſea or lakes, at the bottom of which they had remained in a torpid ſtate during the whole winter. But Mr Kalm, who wiſhes to ſupport the torpidity of ſwallows during the winter, likewiſe informs us, that he himſelf met with them at ſea, nine hundred and twenty miles from any land *.

Theſe, and ſimilar facts, the Hon. Daines Barrington endeavours to explain, by ſuppoſing that birds diſcovered in ſuch ſituations, inſtead of attempting to croſs large branches of the ocean, have been forcibly driven from ſome coaſt by ſtorms, and that they would naturally perch upon the firſt veſſel which came within their view.

In Britain, five ſpecies of ſwallows appear in ſummer and diſappear in winter. 1. The houſe-ſwallow makes its appearance about twenty days earlier than the martin, or any other of the ſwallow tribe. They are often ſeen about the 13th day of April. They diſappear about the end of September. A few days previous to their departure, they aſſemble in great flocks on the tops of houſes, churches, and trees, from whence they are ſuppoſed to take their flight. This unuſual and temporary aſſociation of numbers indicates the impulſe of ſome common inſtinct by which each individual is actuated. The houſe ſwallow is eaſily diſtinguiſhed from the

* Voy. tom. 1. pag. 24.

the other ſpecies by the ſuperior forkineſs of its tail, and by a red ſpot on the forehead, and under the chin. This ſpecies builds in chimneys, and makes its neſt of clay, but leaves the top quite open. 2. The martin is inferior in ſize to the former, and its tail is much leſs forked. The martins appear in Britain ſoon after the houſe-ſwallow. They build under the eaves of houſes: The neſt is compoſed of the ſame materials as thoſe of the houſe-ſwallow; but it is covered above, and a ſmall hole only is left in the ſide for the ingreſs and egreſs of the birds. The martins totally diſappear about the beginning of October. 3. The ſand-martin, or bank-martin, is by much the ſmalleſt of the ſwallow-kind that viſit Britain. The ſand-martins arrive very ſoon after the houſe-ſwallow, and diſappear about Michaelmas. They dig conſiderable holes in ſand-pits and in the banks of rivers, where they build their neſts, which conſiſt not of mud, like thoſe of the former ſpecies, but of graſſes and feathers laid together in a very ſlovenly manner. It is worthy of remark, that theſe birds do not employ the cavities they dig in ſummer for winter-quarters; ſince ſand-banks, ſo perforated, have been carefully ſearched in the winter, and nothing was found but empty neſts *. 4. The ſwift, or black martin of Willoughby, is the largeſt of our ſwallows, and is the lateſt of arriving in this country; for the ſwifts are ſeldom ſeen till the beginning of May, and commonly appear, not in flocks, but in pairs. Swifts, like the ſand-martins, carry on the buſineſs of incubation in the dark. They build in the cranies of caſtles, towers, and ſteeples. Straw and feathers are the materials they uſe. They diſappear very early; for they are almoſt never ſeen after the middle of Auguſt. 5. The goatſucker, which belongs to the ſwallow tribe, is likewiſe a bird of paſſage. Like the other ſwallows, it feeds upon winged inſects. But, inſtead of purſuing its prey during the day, it flies only in the night, and ſeizes moths, and other nocturnal inſects. From this circumſtance, it has not

* White's Natural Hiſtory of Selborne, pag. 177.

not improperly received the appellation of the *nocturnal ſwallow*. The goat-ſucker ſtays only a ſhort time in Britain. It appears not till about the end of May, and retires in the middle of Auguſt. It lays its eggs, which are commonly two, and ſometimes three, on the bare ground.

To give catalogues of the numerous birds of paſſage which frequent this iſland, as well as other countries, and to mark the times of their arrival and departure, would be deviating entirely from our plan. For circumſtances of this kind, the curious may conſult Cateſby, Klein, Linnaei Amoenitates Academicae, White, &c. But, as the periodical appearance and diſappearance of the ſwallow-tribe have given riſe to different theories and opinions, we ſhall briefly relate thoſe opinions, and conclude with ſome remarks on migration in general.

Herodotus and Proſper Alpinus mention one ſpecies of ſwallow which reſides in Egypt during the whole year *; and Mr Loten, late governour of Ceylon, aſſured Mr Pennant, that thoſe of Java never remove. If theſe be excepted, all the other known kinds retreat or migrate periodically. Swallows migrate from almoſt every climate. They remove from Norway †, from North America ‡, from Kamtſchatka §, from the temperate parts of Europe, from Aleppo ||, and from Jamaica **.

Concerning the periodical appearance and diſappearance of ſwallows, there are three opinions adopted by different naturaliſts. The firſt

* Proſp. Alp. tom. 1. pag. 198.

† Pontopp. Hiſt. Norw. ii. 98.

‡ Cateſby's Carol. v. 1. pag. 51. App. 8.

§ Hiſt. Kamtſchatka, pag. 162.

|| Ruſſel's Alep. pag. 70.

** Phil. Tranſ. N° 36.

firſt and moſt probable is, that they remove from climate to climate at thoſe particular ſeaſons when winged inſects, their natural food, fails in one country or diſtrict and abounds in another, where they likewiſe find a temperature of air better ſuited to their conſtitutions. In ſupport of this opinion, we have the teſtimony, as formerly mentioned, of Sir Charles Wager, of M. Adanſon, and of many navigators. It is equally true, however, that ſome ſpecies of ſwallows have been occaſionally found in a torpid ſtate during winter. Mr Collinſon gives the evidence of three gentlemen who were eye-witneſſes to a number of ſand-martins being drawn out of a cliff on the Rhine in the month of March 1762 *. The Hon. Daines Barrington, in the year 1768, communicated to Mr Pennant, on the authority of the late Lord Belhaven, the following fact: 'That numbers 'of ſwallows have been found in old dry walls, and in ſand-hills, 'near his Lordſhip's ſeat in Eaſt Lothian; not once only, but from 'year to year; and that, when they were expoſed to the warmth of 'a fire, they revived †.' Theſe, and other facts of the ſame kind, ſeem to be uncontrovertible; and Mr Pennant infers from them, that 'we muſt divide our belief relating to theſe two ſo different opi'nions, and conclude, that one part of the ſwallow tribe migrate, 'and that others have their winter-quarters near home ‡.' But we ſhould rather incline to think, with thoſe naturaliſts who ſuppoſe that the torpid ſwallows which are occaſionally, though very rarely, diſcovered in the winter ſeaſon, have been obliged to remain behind, becauſe they were too young, weak, diſeaſed, or ſuperannuated, to undertake a long and fatiguing flight. Still, however, that the torpidity of the feathered tribes ſhould be ſolely confined to the ſwallows, is a very ſingular fact in the hiſtory of Nature. Among quadrupeds,

* Philoſoph. Tranſact. vol. 53. pag. 101. art. 24.

† Pennant's Britiſh Zoology, vol. 2. pag. 250. 8vo edit.

‡ Ibid. 251.

drupeds, there are many ſpecies who lie in a dormant or torpid ſtate during winter. But, if the ſwallow be excepted, not a ſingle ſpecies of birds, notwithſtanding the great numbers which, at ſtated times, appear and diſappear in every corner of the globe, has ever been diſcovered in that ſtate. This circumſtance alone, though we cannot yet aſcertain the preciſe places to which different ſpecies of birds of paſſage reſort, is a moſt convincing proof of migration in general.

It has been aſſerted, and even believed, by ſome naturaliſts, that ſwallows paſs the winter immerſed under the ice, at the bottom of lakes, or beneath the waters of the ſea. Olaus Magnus, Archbiſhop of Upſal, ſeems to have been the firſt who adopted this opinion. He informs us, that ſwallows are found in great cluſters at the bottoms of the northern lakes, with mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their ſubterraneous retreats *. ‘ That the good Archbiſhop,’ Mr Pennant archly remarks, ‘ did not want credulity in other inſtances, appears from ‘ this, that, after having ſtocked the bottoms of the lakes with birds, ‘ he ſtores the clouds with mice, which ſometimes fall in plentiful ‘ ſhowers on Norway and the neighbouring countries!’ Klein has endeavoured to ſupport the notion that ſwallows lie under water during the winter, and gives the following account of their manner of retiring, which he collected from ſome countrymen: They aſſerted, he tells us, that the ſwallows ſometimes aſſembled in numbers on a reed till it broke and ſunk them to the bottom: That their immerſion was preceded by a kind of dirge, which laſted more than a quarter of an hour: That others united, laid hold of a ſtraw with their bills, and plunged down in ſociety: That others, by clinging together with their feet, formed a large maſs, and in this manner committed themſelves to the deep †.

Two

* Derham's Phyſ.-Theol. pag. 349.

† Klein Prod. Hiſt. Avium, pag. 205.—206.

Two reafons feem to render this fuppofed fubmerfion of fwallows impoffible. In the firft place, no land-animal can exift fo long without fome degree of refpiration. The otter, the feal, and water-fowls of all kinds, when confined under the ice, or entangled in nets, foon perifh; yet it is well known, that animals of this kind can remain much longer under water than thofe who are deftitute of that peculiar ftructure of the heart which is neceffary for any confiderable refidence beneath that penetrating element. Mr John Hunter, in a letter to Mr Pennant, informs us, 'That he had dif-'fected many fwallows, but found nothing in them different from 'other birds as to the organs of refpiration: That all thofe animals 'which he had diffected of the clafs that fleep during winter, fuch 'as lizards, frogs, &c. had a very different conformation as to thofe 'organs: That all thofe animals, he believes, do breathe in their 'torpid ftate; and, as far as his experience reaches, he knows they 'do; and that, therefore, he efteems it a very wild opinion, that 'terreftrial animals can remain any long time under water without 'drowning.' Another argument againft their fubmerfion arifes from the fpecific gravity of the animals themfelves. Of all birds, the fwallow tribes are perhaps the lighteft. Their plumage, and the comparative fmallnefs of their weight, indicate that Nature deftined them to be almoft perpetually on the wing in queft of food. From this fpecific lightnefs, the fubmerfion of fwallows, and their continuing for months under water, amount to a phyfical impoffibility. Even water-fowls, when they wifh to dive, are obliged to rife and plunge with confiderable exertion, in order to overcome the refiftence of the water. Klein's idea of fwallows employing reeds and ftraws as means of fubmerfion is rather ludicrous; for thefe light fubftances, inftead of being proper inftruments for affifting them to reach the bottom, would infallibly contribute to fupport them on the furface, and prevent the very object of their intention. Befides, admitting the poffibility of their reaching the bottom of lakes and feas, and fuppofing they could exift for feveral months without refpiration, What would be the confequence? The whole would foon be devoured by otters, feals, and fifhes of various kinds. Nature is always anxious for the prefervation of fpecies. But, if the fwallow tribes were deftined to remain torpid, during the winter months, at the bottom of lakes and feas, fhe would act in oppofition to her own intentions; for, in a feafon or two, the whole genus would be annihilated.

Mr White of Selborne has favoured us with the following information concerning the migration of fwallows: 'If ever I faw,' fays he, 'any thing like actual migration, it was laft Michaelmas day, '1768. I was travelling, and out early in the morning: At firft 'there was a vaft fog; but, by the time that I was got feven or 'eight miles from home towards the coaft, the fun broke out into a 'delicate warm day. We were then on a large heath or common, 'and I could difcern, as the mift began to break away, great num-'bers of fwallows cluftering on the ftinted fhrubs and bufhes, as if 'they had roofted there all night. As foon as the air became clear 'and pleafant, they all were on the wing at once, and, by a placid 'and eafy flight, proceeded on fouthward towards the fea: After 'this I did not fee any more flocks, only now and then a ftraggler. 'When I ufed to rife in a morning laft autumn, and fee the fwal-'lows and martins cluftering on the chimneys and thatch of the 'neighbouring cottages, I could not help being touched with fecret 'delight, mixed with fome degree of mortification: With delight, 'to obferve with how much ardour and punctuality thofe poor lit-'tle birds obeyed the ftrong impulfe towards migration, or hiding, 'imprinted on their minds by their great Creator; and with fome 'degree of mortification, when I reflected, that, after all our pains 'and inquiries, we are yet not quite certain to what regions they

'do

' do migrate; and are ſtill farther embarraſſed to find, that ſome do ' not actually migrate at all *.'

In another part of his work, Mr White ſays: ' But we muſt not ' deny migration in general; becauſe migration certainly does ſub- ' ſiſt in ſome places, as my brother in *Andaluſia* has fully informed ' me. Of the motions of theſe birds he has ocular demonſtration, ' for many weeks together, both ſpring and fall: During which pe- ' riods, myriads of the ſwallow kind traverſe the Straits from north ' to ſouth, and from ſouth to north, according to the ſeaſon. And ' theſe vaſt migrations conſiſt not only of *hirudines* (ſwallows), but ' of *bee-birds*, *hoopoes*, *oropendulos*, or *golden thruſhes*, &c. &c. and ' alſo many of our *ſoft billed ſummer birds of paſſage*; and, more- ' over, of birds which never leave us, ſuch as all the various ſorts of ' hawks and kites. Old Belon, two hundred years ago, gives a cu- ' rious account of the incredible armies of hawks and kites, which ' he ſaw in the ſpring-time traverſing the Thracian Boſphorus from ' Aſia to Europe. Beſides the above mentioned, he remarks, that ' the proceſſion is ſwelled by whole troops of eagles and vultures †.'

Mr White likewiſe, with much propriety, remarks, that our inquiries concerning the migration of birds have been too much confined to the ſwallow tribes; while little attention has been paid to the ſhort-winged birds of paſſage, ſuch as quails, red-ſtarts, nightingales, white-throats, black-caps, &c. All theſe, though ſeemingly ill qualified for long flights, diſappear in the winter, and not one of them, notwithſtanding their immenſe numbers, has ever been found in a torpid ſtate.

* White's Natural Hiſtory of Selborne, pag. 64.—65.

† Ibid. pag. 139.

To mark the times of the arrival and departure of birds of paſſage in different countries, and in different diſtricts of the ſame countries, and the probable motives ariſing from the ſtate of the country with regard to heat and cold, and to that of the food peculiar to each kind, would throw much light upon the hiſtory of migration. To Mr White of Selborne we are obliged for the following liſts of birds of paſſage which he has obſerved in his neighbourhood. Theſe liſts are arranged nearly in the order of time.

Liſt of Summer Birds of Paſſage.

Names.	*Uſually appear about*
1. Wryneck,	Middle of March.
2. Smalleſt willow-wren,	March 23.
3. Houſe-ſwallow,	April 13.
4. Martin,	Ibid.
5. Sand-martin,	Ibid.
6. Black-cap,	Ibid.
7. Nightingale,	Beginning of April.
8. Cuckoo,	Middle of April.
9. Middle willow-wren,	Ibid.
10. White-throat,	Ibid.
11. Red-ſtart,	Ibid.
12. Stone-curlew,	End of March.
13. Turtle-dove,	———
14. Graſshopper lark,	Middle of April.
15. Swift,	April 27.
16. Leſs reed-ſparrow,	———
17. Land-rail,	———
18. Largeſt willow-wren,	End of April.
19. Goat-ſucker, or fern-owl,	Beginning of May.
20. Fly-catcher,	May 12. This is the lateſt ſummer bird of paſſage.

Moſt

Moſt ſoft-billed birds feed upon inſects, and not on grain or ſeeds; and, therefore, they retire before winter. But the following ſoft-billed birds, though they eat inſects, remain with us during the whole year; ſuch as the red-breaſt and wren, who frequent out-houſes and gardens during the winter, and eat ſpiders, &c.; the hedge-ſparrow, who frequents ſinks for crumbs and other ſweepings; the white wagtail, the yellow wagtail, and the gray wagtail, who frequent ſhallow rivulets near the ſpring heads, where the water ſeldom freezes, and feed upon the aureliae of inſects; the wheat-ear, ſome of which are to be ſeen during the winter, &c.

Liſt of Winter Birds of Paſſage in the neighbourhood of Selborne.

1. The ring-ouſel. This bird appears about Michaelmas week, and is a new migration lately diſcovered by Mr White.

2. The red-wing, or wind-thruſh, appears in Britain about old Michaelmas. They come in great flocks from the frozen regions of the north.

3. Field-fare. Theſe birds viſit Britain in immenſe numbers about Michaelmas, and depart about the end of February, or the beginning of March. They paſs the ſummer in the northern parts of Europe, and likewiſe in Lower Auſtria *. They breed in the largeſt trees, feed on berries of all kinds †, but prefer thoſe of the juniper. It is probable that the field-fares which migrate into Britain come from Norway and the northern regions of Europe, becauſe

* Kramer Elench. pag. 361.

† Linn. Faun. Suec. ſp. 78.

caufe we find that they both breed and winter in Pruffia, Auftria *, and the more temperate climates.

4. The Royfton-crow, or hooded crow of our countryman Sir Robert Sibbald, is likewife a bird of paffage. It vifits us in the beginning of winter, and departs with the wood-cocks. They frequent the inland as well as the maritime parts of Britain. When near the coafts, they feed upon crabs, mufcles, and other fhell-fifhes. They breed in Sweden, build their nefts in trees, and lay four eggs †. They likewife breed in the fouthern parts of Germany, and particularly on the banks of the Danube ‡.

5. The wood-cock appears in this country about old Michaelmas. During the fummer, wood-cocks inhabit the Alps ‖, Norway, Sweden §, and the northern parts of Europe. From thefe countries they retire as foon as the froft commences, which obliges them to migrate into milder climates, where the foil is open, and more adapted to their mode of feeding; for they live on worms, which they fearch for with their long bills in foft and moift grounds in the midft of woods. Wood-cocks, taking the advantage of the night, or of foggy weather, arrive here in flocks: But they foon feparate; and, before returning to their fummer quarters, they pair. They fly and feed during the night. They begin their flight in the evening, and return to their retreats in the glades when day commences. They depart from Britain about the end of February or the beginning of March. Some of them, however, like the ftraggling fwallows, have been known to breed, and to remain here during the whole year.

* Klein Hift. Avium. pag. 178.

† Linn. Faun. Suec. fp. 88.

‡ Kramer, pag. 333.

‖ Willoughby's Ornithology, pag. 290.

§ M. de Geer's and Dr Wallerius's letters to Mr Pennant.

year *. It is likewiſe known that wood-cocks migrate from France, Germany, and Italy, and that they make choice of cold northern climates for their ſummer reſidence. About the end of October they viſit Burgundy, but remain there four or five weeks only; becauſe it is a dry country, and, on the firſt froſts, they are obliged to retire for want of ſuſtenance. In the winter, they are found as far ſouth as Smyrna, Aleppo †, and Barbary ‡. They are even very common in Japan ‖.

6. The ſnipe. Snipes are enrolled as birds of paſſage by Mr White, though he acknowledges that ſome of them conſtantly breed in England. ' In winter,' Mr Pennant remarks, ' ſnipes are very ' frequent in all our marſhy and wet grounds, where they lie con- ' cealed in the ruſhes, &c. In the ſummer, they diſperſe to diffe- ' rent parts, and are found in the midſt of our higheſt mountains, ' as well as our low moors. Their neſt is made of dried graſs. ' They lay four eggs of a dirty olive colour, marked with duſky ' ſpots. Their young are ſo often found in England, that we doubt ' whether they ever entirely leave this iſland §.'

7. The jack-ſnipe. This bird, which is very common in Scotland, and frequents the banks of rivers and lakes, is ranked by Mr White as a winter bird of paſſage, without mentioning either the time of its arrival or departure; and Mr Pennant is entirely ſilent on the ſubject **.

8. The

* Pennant's Britiſh Zoology, vol. 2. pag. 349. 8vo.

† Ruſſel's Hiſtory of Aleppo, pag. 64.

‡ Shaw's Travels, pag. 253.

‖ Kaempfer's Hiſt. Japan. vol. 1. pag. 129.

§ Pennant's Britiſh Zoology, vol. 2. pag. 358. 8vo.

** White's Natural Hiſtory of Selborne, pag. 117.; and Pennant's Britiſh Zoology, vol. 2. pag. 359. 8vo.

8. The wood-pigeon. Mr White, without mentioning either the time of their appearing or diſappearing, tells us, that 'they ſeldom 'appear till late; nor in ſuch plenty as formerly *.'

9. The wild-ſwan. During hard winters, this bird frequents the coaſts of Britain in large flocks; but, from any information we have been able to obtain, it does not breed in our iſland. Martin, in his Hiſtory of the Hebrides, or Weſtern Iſles †, informs us, that wild ſwans arrive in great numbers in Lingey, one of the Hebrides, in the month of October, and remain there till March, when they retire more northward to breed. For this purpoſe, the ſwans, like moſt other water-fowls, prefer ſuch places as are leaſt frequented by mankind. During ſummer, the lakes, marſhes, and foreſts of Lapland are filled with myriads of water-fowls. In that northern region, ſwans, geeſe, the duck tribe, gooſanders, divers, &c. paſs the ſummer; but in autumn they return to us, and to other more hoſpitable ſhores ‡.

10. The wild-gooſe. The wild geeſe, it is probable, breed in the retired regions of the north. They arrive here in the beginning of winter, and frequently feed on our corn grounds. They fly at a great heighth, and obſerve regularity in their movements. They ſometimes form a ſtraight line; and, at others, they aſſume the ſhape of a wedge, which facilitates their progreſs through the reſiſting air.

With regard to the wild-duck, pochard, wigeon, and teal, though Mr White places them in the liſt of birds of paſſage, he does not mention either the times of their arrival or departure. Though it be

* White's Natural Hiſtory of Selborne, pag. 117.

† Deſcription of the Weſtern Iſles, pag. 71.

‡ Linn. Flora Lapponica, pag. 273. Oeuvres de Maupertuis, tom. 3. pag. 141.

be probable that moſt of the duck-kind migrate, yet it is certain, that ſome individuals of different ſpecies of them breed in this country, and continue in it during the whole year. As to the duck-kind in general, Mr Pennant remarks: ‘ Of the numerous ſpecies ‘ that form this genus, we know of no more than five that breed ‘ here. The *tame ſwan* and *tame gooſe*, the *Shield duck*, the *eider* ‘ *duck*, and a very ſmall portion of the *wild ducks*. The reſt con‘ tribute to form that amazing multitude of water fowl that annu‘ ally repair from moſt parts of Europe to the woods and lakes of ‘ Lapland, and other Arctic regions *, there to perform the func‘ tions of incubation and nutrition in full ſecurity. They and their ‘ young quit their retreat in September, and diſperſe themſelves over ‘ Europe. With us they make their appearance the beginning of ‘ October, circulate firſt round our ſhores, and, when compelled by ‘ ſevere froſt, betake themſelves to our lakes and rivers †.’

In winter, the bernacles, or brent-ducks, appear in vaſt flocks on the north-weſt coaſts of Britain. They are very ſhy and wild; but, when taken, they ſoon grow as familiar as our domeſtic ducks. They leave the Britiſh ſhores in February, and migrate as far as Lapland, Greenland, and even Spitſbergen ‡.

The ſolan-geeſe, or gannets, are likewiſe birds of paſſage. They frequent the iſle of Ailſay, near the Frith of Clyde; the rocks adjacent to St Kilda, the moſt remote of the Hebrides; the Skelig iſles, off the coaſt of Kerry; and the Baſs iſle in the Frith of Forth. The multitudes which frequent theſe places are prodigious. To give an

* Collect. Voyag. Dutch Eaſt India Company, 8vo, 1703. pag. 19. Cluſii Exot. pag. 368.

† Pennant's Britiſh Zoology, vol. 2. pag. 519.—520.

‡ Linn. Amoen. Acad. tom. 4. pag. 585. Barent's Voyage, pag. 19.

idea of their numbers, the reader will not be difpleafed to fee Dr Harvey's fhort account of the Bafs. 'There is a fmall ifland in the 'Frith of Forth, called the *Bafs Ifland*, which does not exceed a 'mile in circumference. The furface of this ifland, during the 'months of May and June, is fo entirely covered with nefts, eggs, 'and young birds, that it is fcarcely poffible to walk without tread'ing on them. The flocks of birds on the wing are fo prodigious, 'that they darken the air like clouds, and their noife is fo great, 'that a man cannot without difficulty hear his neighbour's voice. 'If, from the top of the precipice, you look down upon the fea, 'you will fee it on every fide covered with infinite numbers of 'birds of different kinds, fwimming about and hunting for their 'prey. When failing round the ifland, if you furvey the hanging 'cliffs, you will perceive, in every cragg, or fiffure of the rocks, in'numerable birds of various kinds, more than the ftars of heaven 'in a ferene night. If you view the diftant flocks, either flying to 'or from the ifland, you will imagine them to be a vaft fwarm of 'bees *.' The rocks of St Kilda feem to be equally frequented by folan geefe; for Martin, in his defcription of the Hebrides, informs us, that the inhabitants of this fmall ifland confume annually no lefs than 22,600 young birds of this fpecies, befide an amazing number of their eggs. The folan geefe and their eggs conftitute the chief food of thefe iflanders. They preferve both the fowls and the eggs in fmall pyramidal ftone buildings, which, to protect the food from moifture, they cover with the afhes of turf. The folan geefe are birds of paffage. Their firft appearance is in March, and they continue till Auguft or September. But, in general, the times of their breeding and departure feem to coincide with the arrival of the herring, and the migration of that fifh from our coafts. It is more than probable that thefe birds attend the herrings and pilchards during their whole

* Harvey de Generat. Animal. Exercit. 11.

whole circuit round the Britiſh iſlands; for the appearance of the ſolan geeſe is always eſteemed by the fiſhermen as a certain preſage of the approach of the herrings or pilchards. In queſt of food, theſe birds migrate as far ſouth as the mouth of the Tagus; for they are frequently ſeen off Liſbon during the month of December.

The croſs-beak, the croſs-bill, and the ſilk-tail, are likewiſe enumerated by Mr White as birds of paſſage. 'But theſe,' ſays he, 'are only wanderers that appear occaſionally, and are not obſervant 'of any regular migration *.'

The long-legged plover, and ſanderling, viſit us in winter only; and it is worthy of remark, that every ſpecies of the curlews, wood-cocks, ſand-pipers, and plovers †, which forſake us in the ſpring, retire to Sweden, Polland, Pruſſia, Norway, and Lapland, both to feed and to breed. They return to us as ſoon as the young are able to fly; becauſe the froſts, which ſet in early in theſe countries, totally deprive them of the means of ſubſiſtance. For the ſame reaſon they leave us in ſummer, as the dryneſs and hardneſs of the ground prevent them from penetrating the earth with their bills in queſt of worms, which conſtitute the natural food of theſe birds.

From the facts which have been enumerated, and from others of a ſimilar nature, it is evident, that many birds, both of the land and water kinds, migrate from one climate to another. But, even in the ſame climate and country, birds occaſionally perform partial migrations. During hard winters, when the ſurface of the earth is covered with ſnow, many birds, as larks, ſnipes, &c. retire

 from

* White's Natural Hiſtory of Selborne, pag. 118.

† Linn. Amoen. Acad. tom. 4. pag. 588. Klein de Avium Migrat. pag. 187.

from the inland parts of the country to the ſea-ſhores, where they pick up a ſcanty ſubſiſtance. Others, as the wren, the red-breaſt, and many of the ſmall birds, or ſparrow-kind, reſort to gardens, and the habitations of men. Their intention, it is obvious, is to procure food and ſhelter.

There are three principal objects of migration: Food, temperature of air, and convenient ſituations for breeding. Such birds as migrate to great diſtances are alone denominated *birds of paſſage.* But all birds are, in ſome meaſure, birds of paſſage, though they do not migrate to places ſo remote from their former abodes. At particular times of the year, moſt birds migrate from one county to another, or from the more inland diſtricts toward the ſhores. Theſe partial migrations of ſmall birds are well known to bird-catchers, who make a liveliehood by enſnaring them into their nets, and ſelling them. The birds *fly*, as the bird-catchers term it, about the end of September, and during the months of October and November. There is another, but leſs conſiderable, flight in March. Some begin their flight annually about Michaelmas; others, as the wood-larks, ſucceed, and continue their flight till the middle of October; but the green-finch does not migrate till the froſt obliges it to remove in queſt of food and ſhelter. Theſe partial migrations, or flittings, are performed from day-break till noon. Another, but ſmaller, flight commences at two o'clock, and continues till night approaches. The times when particular birds migrate from one ſituation to another are well known to the bird-catchers, who, by means of call-birds, nets, and other devices, ſeize great numbers of them, and, after accuſtoming them for ſome time to reſtraint and ſlavery, ſell them, for conſiderable prices, to curious men and whimſical women. A diligent attention to theſe partial migrations, and their motives, would ſoon unfold the cauſes of thoſe of a more extenſive kind.

Migration

Migration is generally ſuppoſed to be peculiar to the feathered tribes. This is a limited idea, which has originated from inattention to the oeconomy of Nature. Birds migrate with a view to remedy the inconveniencies of their preſent ſituation, and to acquire a more commodious ſtation with regard to food, temperature, generation, and ſhelter. From ſimilar motives, men, ſometimes in amazing multitudes, have migrated from north to ſouth, diſplaced the native inhabitants, and fixed eſtabliſhments in more comfortable climates than thoſe which they had relinquiſhed. Theſe, in their turn, have fallen victims to freſh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden, Scotland, &c. notwithſtanding a very ſtrong attachment to their native countries, there ſeems to be a natural or inſtinctive propenſity to migrate. Poverty, the rigour of climate, curioſity, ambition, the falſe repreſentations of intereſted individuals, the oppreſſion of feudal barons, and ſimilar circumſtances, have of late given riſe to great emigrations of the human ſpecies. But, it is worthy of remark, that the emigrations from ſouth to north, except from the love of conqueſt in ambitious nations, are ſo rare, that the inſtinct ſeems hardly to exiſt in thoſe more fortunate climates. Curioſity is a general inſtinctive principle, which operates ſtrongly in the youthful periods of life, and ſtimulates every man to viſit places that are diſtant from his ordinary reſidence. This innate deſire is influenced by the relations of travellers, and by many other incentives of a more intereſted kind. Without the principle of migration, mankind, it is probable, would never have been ſo univerſally diffuſed over the ſurface of the earth. It is counterbalanced, however, by attachment to thoſe countries which gave us birth, a principle ſtill more powerful and efficient. Love of our native country is ſo ſtrong, that, after gratifying the migrating principle, almoſt every man feels a longing deſire to return.

Savages, as long as their ſtore of food remains unexhauſted, continue in a liſtleſs inactive ſtate. They exhauſt many days ſitting in perfect indolence, and ſeem not to be prompted by any motives of curioſity. They have not a conception of a man's walking either for amuſement or exerciſe. But, when their proviſions begin to fail, an aſtoniſhing reverſe takes place. They then rouſe as from a profound ſleep. In queſt of wild beaſts, birds, and fiſhes, they migrate to immenſe diſtances, exert the greateſt feats of activity, and undergo incredible hardſhips and fatigue. After acquiring a ſtore of proviſions, they return to their wonted haunts, and remain inactive till their food again begins to fail.

Quadrupeds likewiſe perform partial migrations. At the approach of winter, the ſtag, the rein-deer, and the roebuck, leave the tops of the lofty mountains, and come down to the plains and copſes. Their chief objects, in theſe flittings, are food and ſhelter. When ſummer commences, they are harraſſed with different ſpecies of winged inſects, and, to avoid theſe enemies, they regain the ſummits of the mountains, where the cold and the heighth of the ſituation protect them from the attacks of the flies. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the ſhores of the ſea, where they feed upon ſea-plants and the bones of fiſhes; and Pontoppidan remarks, that the cattle know by inſtinct when the tide retires, and leaves theſe articles of food upon the ſhore. In Orkney and Shetland, the ſheep in winter, for the ſame purpoſes, uniformly repair to the ſhore at the ebbing of the tides. Rats, particularly thoſe of the northern regions of Europe, appear, from time to time, in ſuch myriads, that the inhabitants of Norway and Lapland imagine the animals fall from heaven. The celebrated Linnaeus, who paid great attention to the oeconomy of theſe migrating rats, remarked, that they appeared in Sweden periodically every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and aſſemble together in numbers inconceivable. In the courſe of their journey, they make tracks in the earth of two inches in depth; and theſe tracks ſometimes occupy a breadth of ſeveral fathoms. What is ſingular, the rats, in their march, uniformly purſue a ſtraight line, unleſs they are forced to turn aſide by ſome unſurmountable obſtacle. If they meet with a rock, they firſt try to pierce it, and, after diſcovering the attempt to be impracticable, they go round it, and then reſume the ſtraight line. Even a lake does not interrupt their paſſage; for they either traverſe it in a ſtraight line or periſh in the attempt; and, if they meet with a bark or other veſſel, they do not alter their direction, but climb up the one ſide of it and deſcend by the other.

Frogs, immediately after their transformation from the tadpole ſtate, leave the water, and migrate to the meadow or marſhy grounds in queſt of inſects. The numbers of young frogs which ſuddenly make their appearance in the plains induced Rondeletius, and many other naturaliſts, to imagine that they were generated in the clouds and ſhowered down upon the earth. But if, like the worthy and intelligent Mr Derham, they had examined the ſituation of the place with regard to ſtagnating waters, and attended to the nature and transformation of the animals, they would ſoon have diſcovered the real cauſe of the phenomenon.

Of all migrating animals, particular kinds of fiſhes make the longeſt journies, and in the greateſt numbers. The multiplication of the ſpecies, and the procuring of food, are the principal motives of the migration of fiſhes. The ſalmon, a fiſh which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean ſea, and in the rivers which fall into it both from Europe and Africa. It is found in ſome of the rivers of France

that

that empty themſelves into the ocean *. Salmons are taken in the rivers of Kamtſchatka †, and appear as far north as Greenland. Salmons live both in the ocean and in freſh waters. For the purpoſe of depoſiting their ſpawn, they quit the ſea in the month of September, and aſcend the rivers. So ſtrong is the inſtinct of migrating, that they preſs up the rivers with amazing keenneſs, and ſcarcely any obſtacle is ſufficient to interrupt their progreſs. They ſpring, with great agility, over cataracts of ſeveral feet in heighth. In their leaps, they ſpring ſtraight up with a ſtrong tremulous motion, and do not, as has been vulgarly ſuppoſed, put their tails in their mouths. When they find a place which they think proper for depoſiting their eggs, the male and female unite their labours in forming a convenient receptacle for the ſpawn in the ſand, which is generally about eighteen inches deep. In this hole the female depoſits her eggs, and the male his milt, which they are ſaid to cover carefully with their tails; for, after ſpawning, their tails are deprived of ſkin. The eggs, when not diſturbed by violent floods, lie buried in the ſand till the ſpring, and they are hatched about the end of March. The parents, however, after this important office has been performed, haſten back to the ſea, in order to cleanſe themſelves, and to recover their ſtrength. Toward the end of March, the young fry begin to appear, and they gradually increaſe in ſize till they acquire the length of four or five inches, and are then called *ſmelts*, or *ſmoults* ‡. About the beginning of May, all the conſiderable rivers of Scotland are full of ſalmon-fry. After this period, they migrate to the ſea. About the middle of June, the earlieſt of the fry begin to appear again in the rivers. At that time they are from

* Rondelet. de Fluviat. pag. 167.

† Hiſt. Kamtſchatka, pag. 143.

‡ See an Account of the Salmon Fiſhery on the River Tweed, communicated to Mr Pennant by Mr Potts, Brit. Zool. vol. 3. pag. 241. 8vo edit.

from twelve to ſixteen inches long, and gradually augment, both in number and ſize, till about the end of July or the beginning of Auguſt, when they weigh from ſix to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr Pennant of a growth ſtill more rapid. A ſalmon, weighing ſeven pounds and three quarters, was taken on the ſeventh day of February. It was marked on the back, fin, and tail, with ſciſſars, and then turned into the river. It was retaken on the 17th day of the following month of March, and then it weighed ſeventeen pounds and a half. The ſeaſon for fiſhing ſalmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that ſingle river, it is computed that no leſs than 208000, at a medium, are annually caught, which, together with the products of many other rivers on both ſides of Scotland, not only afford a wholeſome and palatable food to the inhabitants, but form no inconſiderable article of commerce.

Herrings are likewiſe actuated by the migrating principle. Theſe fiſhes are chiefly confined to the northern and temperate regions of the globe. They frequent the higheſt latitudes, and are ſometimes found on the northern coaſts of France. They appear in vaſt ſhoals on the coaſt of America, as far ſouth as Carolina. In Cheſapeak Bay there is an annual inundation of herrings; and Mr Cateſby informs us, that they cover the ſhores in ſuch amazing numbers as to become offenſive to the inhabitants. The great winter rendezvous of the herrings is within, or near, the Arctic Circle, where they remain ſeveral months, and acquire ſtrength after being weakened by the fatigues of ſpawning, and of a long migration. In theſe ſeas, inſect food is much more abundant than in warmer latitudes. They begin their migration ſouthward in the ſpring, and appear off the Shetland iſlands in the months of April and May. Theſe, however, are only the forerunners of the immenſe ſhoal which arrives in June.

Their approach is recognifed by particular figns, fuch as the appearance of certain fifhes, the vaft number of birds, as gannets or folan geefe, which follow the fhoal to prey upon the herrings. But, when the main body arrives, its breadth and depth are fo great as to change the appearance of the ocean itfelf. The fhoal is generally divided into columns of five or fix miles in length, and three or four in breadth. Their progreffive motion creates a kind of rippling or fmall undulations in the water. They fometimes fink and difappear for ten or fifteen minutes, and then rife again toward the furface. When the fun fhines, a variety of fplendid and beautiful colours are reflected from their bodies. In their progrefs fouthward, the firft interruption they meet with is from the Shetland iflands. Here the fhoal divides into two branches. One branch fkirts the eaftern, and the other the weftern fhores of Great Britain, and fill every bay and creek with their numbers. Thofe which proceed to the weft from Shetland, after vifiting the Hebrides, where the great fifhery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a fecond time. One divifion takes to the weft, where they are fcarcely perceived, being foon loft in the immenfity of the Atlantic Ocean. The other divifion goes into the Irifh Sea, and affords nourifhment to many thoufands of the human race. The chief object of herrings migrating fouthward is to depofit their fpawn in warmer and more fhallow feas than thofe of the Frigid Zone. This inftinct feems not to be prompted by a fcarcity of food; for, when they arrive upon our coafts, they are fat and in fine condition; but, when returning to the ocean, they are weak and emaciated. They continue in perfection from the end of June to the beginning of winter, when they begin to depofit their fpawn. The great ftations of the herring fifheries are off the Shetland and the weftern iflands, and along the coaft of Norfolk.

Befide

Beſide ſalmons and herrings, there are many fiſhes which obſerve a regular migration, as mackerels, lampreys, pilchards, &c. About the middle of July, the pilchards, which are a ſpecies of herrings, though ſmaller, appear in vaſt ſhoals off the coaſts of Cornwall. When winter approaches, like the herrings, they retire to the Arctic ſeas. Though ſo nearly allied to the herring, it is not incurious to remark, that the pilchards, in their migration for the purpoſe of ſpawning, chooſe a warmer latitude; for, off the coaſts of Britain, the great ſhoals never appear farther north than the county of Cornwal and the Scilly iſlands. Dr Borlaſe, in his hiſtory of Cornwal, gives the following account of the pilchard fiſhery: ‘ It employs,’ ſays he, ‘ a great number of men on the ſea, training them thereby ‘ to naval affairs; employs men, women, and children, at land, in ‘ ſalting, preſſing, waſhing, and cleaning, in making boats, nets, ‘ ropes, caſks, and all the trades depending on their conſtruction and ‘ ſale. The poor is fed with the offals of the captures, the land with ‘ the refuſe of the fiſh and ſalt; the merchant finds the gains of ‘ commiſſion and honeſt commerce, the fiſherman the gains of the ‘ fiſh. Ships are often freighted hither with ſalt, and into foreign ‘ countries with the fiſh, carrying off, at the ſame time, part of our ‘ tin. The uſual produce of the number of hogſheads exported ‘ each year, for ten years, from 1747 to 1756 incluſive, from the ‘ four ports of Tawy, Falmouth, Penzance, and St Ives, it appears, ‘ that Tawy has exported yearly 1732 hogſheads; Falmouth, 14631 ‘ hogſheads and two-thirds; Penzance and Mounts-Bay, 12149 ‘ hogſheads and one-third; St Ives, 1282 hogſheads: In all amount- ‘ ing to 29795 hogſheads. Every hogſhead, for ten years laſt paſt, ‘ together with the bounty allowed for each hogſhead exported, and ‘ the oil made out of each hogſhead, has amounted, one year with ‘ another at an average, to the price of one pound thirteen ſhillings ‘ and three pence; ſo that the caſh paid for pilchards exported has, ‘ at a medium, annually amounted to the ſum of L. 49532 : 10 : 0.’

Of the land-crab there are ſeveral ſpecies. The migration of what is called the *violet land-crab* deſerves ſome notice. It inhabits the warmer regions of Europe: But its particular reſidence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are, of courſe, moſt remote from the ſea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themſelves dig in the earth. They are extremely numerous. In the months of April and May, they leave their retreats in the mountains, and march in millions to the ſea-ſhore. At this period the whole ground is covered with them; and a man can hardly put down his foot without treading on them *. The object of their migration is to depoſit their ſpawn on the ſea-ſhore. In their progreſs towards the ſea, like the northern rats, the land-crabs move in a ſtraight line. Even when a houſe intervenes, inſtead of deviating to the right or left, they attempt to ſcale the walls. But, when they meet with a river, they are obliged to wind along the courſe of the ſtream. In their migration from the mountains, they obſerve the greateſt regularity, and commonly divide into three battalions or bodies. The firſt conſiſts of the ſtrongeſt and boldeſt males, who, like pioneers, march forward to clear the route, and to face the greateſt dangers. The females, who form the main body, deſcend from the mountains in regular columns, which are fifty paces broad, three miles long, and ſo cloſe that they almoſt entirely cover the ground. Three or four days afterwards, the rear-guard follows, which conſiſts of a ſtraggling undiſciplined troop of males and females. They travel chiefly during the night; but, if it rains by day, (for moiſture facilitates their motion), they proceed in their ſlow uniform manner. When the ſun ſhines, and the ſurface of the ground is dry, they make an univerſal halt till the evening, and then reſume their march. When alarmed

* Voyage aux Iſles Francoiſes par Labat, tom. 2. pag. 221.

alarmed with danger, they run backward in a diforderly manner, and hold up their nippers in a threatening pofture. They even feem to intimidate their enemies; for, when difturbed, they make a clattering noife with their nippers. But, though they endeavour to render themfelves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is fo maimed that he cannot proceed, his companions immediately devour him, and then purfue their journey. After a fatiguing and tedious march, which fometimes continues three months before they reach the fhore, they prepare themfelves for depofiting their fpawn. The eggs ftill remain in the bodies of the animals, and are not excluded, as ufual to this genus, under the tail. To facilitate the maturation and exclufion of the eggs, the land-crabs no fooner arrive on the fhore, than they approach to the margin of the fea, and allow the waves to pafs feveral times over their bodies. They immediately retire to the land; the eggs, in the mean time, come nearer to maturity, and the animals once more go to the water, depofit their eggs, and leave the event to Nature. The bunches of fpawn are fometimes as large as a hen's egg; and it is not incurious to remark, that, at this very period, numbers of fifhes of different kinds are anxioufly waiting for this annual fupply of food. Whether the painful migration of the land-crabs, or the wonderful inftinct of the fifhes which await their arrival, in order to devour their fpawn, is the moft aftonifhing fact, we fhall leave to the confideration of philofophers. The eggs which efcape thefe voracious fifhes are hatched under the fand. Soon after, millions of minute crabs are feen leaving the fhore, and migrating flowly toward the mountains. Moft of the old ones, however, remain in the flat parts of the country till they regain their ftrength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old fhells, remain quite naked, and almoft without motion for fix days, when they become fo fat that they are efteemed delicious food. When the new fhell has

has hardened, the animals, by an inſtinctive impulſe, march back to thoſe mountains which they had formerly deſerted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies; and they are ſo abundant, that the ſlaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles: It extends to many of the *inſect* tribes. Numberleſs inhabitants of the air paſs the firſt ſtages of their exiſtence in the waters. There they remain for longer or ſhorter periods, according to the ſpecies. Previous to their transformation into chryſalids, they quit the waters, and come upon dry ground, where they undergo their amazing change. Inſtead of active water-worms, they dig or find holes in the earth, where they are converted into chryſalids, or ſeemingly inanimated beings, and, in a ſhort time, mount into the air in the form of winged inſects. Similar migrations are to be obſerved among land-inſects. But migration is not confined to water-worms. Many ſpecies of caterpillars which feed upon the leaves of trees, ſhrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, deſcend from the trees, and conceal themſelves in the earth. The hiving of bees, when numerous colonies remove in order to eſtabliſh new ſettlements, is another inſtance of the migration of inſects. Indeed, if we except bees, waſps, ants, and a few others, moſt inſects, whether they inhabit the air, the earth, or the waters, are perfect wanderers, having no fixed place of reſidence. Some of them, as the ſpider tribes, build temporary appartments; but, when diſturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the deſire of changing ſituations, is not confined to particular birds, but extends through almoſt the

whole

whole ſyſtem of animation. Men, quadrupeds, birds, fiſhes, reptiles, inſects, all afford ſtriking examples of the migrating principle. From the ſame facts it is equally apparent, that the general motives for migrating are ſimilar in every claſs of animals. Food, multiplication of ſpecies, and a comfortable temperature of air, are evidently the chief cauſes which induce animals to remove from one place to another, or, what amounts to the ſame thing, from one climate to another. Partial emigrations, or emigrations to ſmall diſtances, are prompted by the ſame inſtinctive motives which induce animals of a different ſtructure to undertake long and fatiguing excurſions. But, previous to actual migration, what are the peculiar feelings of different animals, and what ſhould ſtimulate them to proceed uniformly in the direction that ultimately leads them to the ſituations moſt accommodated to their wants and their conſtitutions, are myſteries, with regard to which, like every other part of the oeconomy of Nature, it is the duty of philoſophers, inſtead of attempting to puſh their inquiries beyond the bounds of human ability, to obſerve a reſpectable ſilence.

CHAP.

CHAPTER XXI.

Of the Longevity and Diſſolution of Organiſed Bodies.

IT is a law of Nature, though a melancholy one, that all organiſed bodies ſhould be diſſolved. The periods of diſſolution, however, are as various as the ſpecies, and the intentions of Nature in producing them.

In the human kind, the brevity of life is regarded as an object of regret. One half of mankind die before they arrive at eight years of age. From that early period to eighty, beſide the deſtruction of war, and other accidents, Nature kills them annually in millions. Some inſtances may be given of men whoſe lives were prolonged beyond the uſual period of human exiſtence. Such men are not to be envied; nor ſhould they be conſidered as favourites of Nature. With reſpect to maturity of judgment, and a knowledge of the world, no man can be ſaid to exiſt till he paſſes thirty years of age. Give him thirty or thirty-five more, and, in general, both mind and body are viſibly declined. Thoſe people, therefore, who arrive at an extraordinary age may be ſaid to exiſt, but they do not live. All intellectual enjoyments and exertions, which conſtitute the chief dignity and happineſs of man, are gone. There are exceptions; but

but theſe exceptions are confirmations of what we have advanced. Mankind, in the early ages of the world, have been ſaid to live for ſeveral centuries. We mean not to contradict the aſſertion. But we muſt remark, that, if ever men lived ſo long, they muſt have been very different, both in the ſtructure of their bodies and in their manners, from thoſe who now exiſt. From infancy to manhood, there is a gradual growth or extenſion of our organs. After this period, and when we advance in years, the bones harden, the muſcles turn ſtiff, the cartilages are converted into bones, the membranes into cartilages, the ſtomach and bowels loſe their tone, and the whole fabric, inſtead of being ſoft, flexible, and obedient to the inclinations, or even the commands of the mind, becomes rigid, inactive, and feeble. Theſe are the general and progreſſive cauſes of death, and they are common to all animals. There are modes of living more favourable to health than others. But examples are not wanting of men who have arrived at extreme old age, without obſerving either temperance, or any of the other modes of living which are generally ſuppoſed to be favourable to longevity. Some men, who lived temperately, and even abſtemiouſly, have reached to great ages: Others, who obſerved the very oppoſite conduct, who lived freely, and often intemperately, have had their exiſtence equally prolonged. But, in general, notwithſtanding a few exceptions, temperance, a placid and chearful diſpoſition, moderate exerciſe, and proper exertions of mind, contribute, in no uncommon degree, to the prolongation of life.

A few examples of longevity in the human ſpecies, though no general concluſions can be drawn from them, may not be incurious to the reader. We ſhall not go back to a remote and obſcure antiquity, but confine ourſelves to more modern times, when the modes of living were nearly the ſame as they are at preſent.

On this fubject, the celebrated Lord Verulam, in his Sylva Sylvarum *, gives the following paffage, chiefly tranflated from the feventh book of Pliny's Natural Hiftory: 'The year of our Lord feventy-fix, falling into the time of Vefpafian, is memorable; in which we fhall find, as it were, a kalendar of long-lived men: For that year there was a taxing, (now a taxing is the moft authentical and trueft informer touching the ages of men), and in that part of Italy which lieth between the Appennine mountains and the river Po, there were found 124 perfons that either equalled or exceeded an hundred years of age, namely,

'Fifty-four - - -	of 100 years each.
'Fifty-feven - - -	110
'Two - - - -	125
'Four - - - - -	130
'Four - - - - -	135 or 137
'Three - - - -	140

'Befide thefe, Parma, in particular, afforded five, whereof,

'Three were - - - -	120 years each.
'Two - - - - -	130
'One in Bruxelles - - -	125
'One in Placentia - - -	131
'One in Faventia - - -	132

'A certain town, then called Velleiatium, fituate in the hills about Placentia, afforded ten, whereof

'Six were - - - -	110 years each.
'Four - - - - -	120
'One in Rimino, whofe name was Marcus 'Aponius - - -	150.'

The

* Page 293.

The moſt extraordinary inſtance of longevity in Great Britain was exhibited in the perſon of Henry Jenkins. He was a native of Yorkſhire, lived to the amazing age of 169 years, and died on the 8th day of December 1670.

Next to Jenkins, we have the famous Thomas Parre, who was a native of Shropſhire, and died on the 16th day of November 1635, at the age of 152.

Francis Conſiſt, a native of Yorkſhire, aged 150, died in January 1768.

Margaret Forſter, aged 136, and her daughter, aged 104, were natives of Cumberland, and both alive in the year 1771.

William Evans, aged 145, lived in Carnarvon, and ſtill exiſted in the year 1782.

Dumiter Radaloy, aged 140, lived in Harmenſtead, and died on the 16th day of January 1782.

James Bowels, aged 152, lived in Kilingworth, and died on the 15th day of Auguſt 1656.

The Counteſs of Deſmond, in Ireland, ſaw her 140th year.

Mr Ecleſton, a native of Ireland, lived to the age of 143, and died in the year 1691.

John Mount, a native of Scotland, ſaw his 136th year, and died on the 27th day of February 1776.

William Ellis of Liverpool died on the 16th day of Auguft 1780, at the age of 130.

Colonel Thomas Winfloe, a native of Ireland, aged 146, died on the 22d day of Auguft 1766.

John Taylor was born in Carrygill, in the county of Cumberland. He was bred a miner. His father died when John was only four years of age. Poverty obliged him to be fet early to work. During two years he dreffed lead ore for 2 d. a-day. The next three or four years he affifted the miners in removing the ore and rubbifh to the bank, for which he received 4 d. a-day. At this period there happened a great folar eclipfe, which was diftinguifhed in Scotland by the appellation of *Mirk Monday* *. This event, which he always repeated with the fame circumftances, is the chief aera from which John's age has been computed. After labouring many years both in this and the neighbouring kingdom, he died, near Leadhills in Scotland, in the month of May 1770, at the great age of 133.

Though the above modern examples of extraordinary longevity reft chiefly on the authority of periodical publications, yet there is not a doubt, that, in all countries, and at all times, fome perfons of both fexes have arrived at ages far beyond the common periods of human life. If the reader is defirous of feeing many inftances of longevity, he may confult Bacon's *Hiftory of Life and Death* †, Whitehurft's *Inquiry into the Original State and Formation of the Earth* ‡, and Dr Fothergill's *Obfervations on Longevity* ||.

The

* *Mirk*, in the Scottifh dialect, fignifies *dark*; and the eclipfe happened in the year 1652.

† Sylva Sylvarum, pag. 273. &c.

‡ 2d Edit. pag. 165.

|| Annual Regifter, Natural Hiftory divifion, pag. 61.

The general caufes of death have already been mentioned. But, in women, the operation of thefe caufes is frequently retarded. In the female fex, the bones, the cartilages, the mufcles, as well as every other part of the body, are fofter and lefs folid than thofe of men: Neither are they generally fo much fubjected to bodily exertions. Their conftituent parts, accordingly, require more time in hardening to that degree which occafions death. Women, of courfe, ought to live longer than men. This reafoning is confirmed by the bills of mortality; for, upon confulting them, it appears, that, after women have paffed a certain time, they live much longer than men who have reached the fame period. The duration of the lives of animals may, in fome meafure, be eftimated by the time occupied in their growth. An animal, or even a plant, as we learn from experience, which acquires maturity in a fhort time, perifhes much fooner than thofe which are longer in arriving at that period. In the human fpecies, when individuals grow with uncommon rapidity, they generally die young. This circumftance feems to have given rife to the common proverbial expreffion, *Soon ripe foon rotten.* Man grows in ftature till he be fixteen or eighteen years of age; but the thicknefs of his body is not completely unfolded before that of thirty. Dogs acquire their full length in one year; but their growth in thicknefs is not finifhed till the end of the fecond. A man, who continues to grow for thirty years, may live ninety or a hundred: But a dog, whofe growth terminates in two or three years, lives only ten or twelve. The fame obfervation is applicable to moft animals. Fifhes continue to grow for a great number of years. Some of them, accordingly, live during feveral centuries; becaufe their bones and cartilages feldom acquire the denfity of thofe of other animals. It may, therefore, be confidered as a general fact, that large animals live longer than fmall ones, becaufe the former require more time to complete their growth. Thus the caufes of our diffolution are inevitable; and it is equally impoffible to retard that fatal period,

period, as to change the eftablifhed laws of Nature. When the conftitution is found, life may, perhaps, by moderating the paffions, and by temperance, be prolonged for a few years. But the varieties of climate, and of the modes of living, make no material differences with regard to the period of our exiftence, which is nearly the fame in the European, the Negro, the Afiatic, the American, the civilized man and the favage, the rich and the poor, the citizen and the peafant. Neither does the difference of food, or of accommodation, make any change on the duration of life. Men who are fed on raw flefh or dried fifh, on fago or rice, on caffada or roots, live as long as thofe who ufe bread and prepared victuals. If luxury and intemperance be excepted, nothing can alter thofe laws of mechanifm which invariably determine the number of our years. Any little differences which may be remarked in the term of human life, feem to be chiefly owing to the quality of the air. In general, there are more old men in high than in low countries. The mountains of Scotland, of Wales, and of Switzerland, have furnifhed more examples of longevity than the plains of Holland, Flanders, Germany, or Poland. But, if we take a furvey of mankind, whatever be the climate they inhabit, or their mode of living, there is fcarcely any difference in the duration of life. When men are not cut off by accidental difeafes, individuals may every where be found who live ninety or a hundred years. Our anceftors, with few exceptions, never exceeded this period; and, fince the days of David King of the Jews, it has undergone no variation. Befide accidental difeafes, which are more frequent, as well as more dangerous, in the latter periods of life, old men are fubjected to natural infirmities that originate folely from a decay of the different parts of the body. The mufcles lofe their tone, the head fhakes, the hands tremble, the limbs totter, the fenfibility of the nerves is blunted, the cavities of the veffels contract, the fecretory organs are obftructed, the blood, the lymph, and the other fluids, extravafate, and produce all thofe fymptoms

toms and diſeaſes which are commonly aſcribed to a vitiation of the humours. The natural decay of the ſolids, however, appears to be the original cauſe of all theſe maladies. It is true, that a bad ſtate of the fluids proceeds from a depravity in the organization of the ſolids. But the effects reſulting from a noxious change in the fluids produce the moſt alarming ſymptoms. When the fluids ſtagnate, or if, by a relaxation of the veſſels, an extravaſation takes place, they ſoon corrupt, and corrode the weaker parts of the ſolids. Hence the cauſes of diſſolution gradually, but perpetually, multiply, our internal enemies grow more and more powerful, and at laſt put a period to our exiſtence.

With regard to *Quadrupeds*, the cauſes of their diſſolution are preciſely the ſame with thoſe which deſtroy the human ſpecies. The times of their growth bear, likewiſe, ſome proportion to the duration of their lives. But, as we have already given a Table of the ages at which different quadrupeds are capable of multiplying their ſpecies, and of the general duration of their lives, to avoid unneceſſary repetitions, we muſt refer the reader to page 283. of this work.

Some *Birds* afford inſtances of great longevity. In this claſs of animals, the duration of life is by no means proportioned to the times of their growth. Moſt of them acquire their full dimenſions in a few months, and are capable of multiplying the ſpecies the firſt ſpring or ſummer after they are hatched. In proportion to the ſize of their bodies, birds are much more vivacious, and live longer than either men or quadrupeds. Swans have been ſaid to live three hundred years; but, though mentioned by reſpectable writers, the aſſertion is not ſupported by any authentic evidence. Mr Willoughby, in his Ornithology *, remarks, 'We have been aſſured by a 'friend

* Page 14.

'friend of ours, a perſon of very good credit, that his father kept 'a gooſe known to be fourſcore years of age, and as yet ſound and 'luſty, and like enough to have lived many years longer, had he 'not been forced to kill her for her miſchievouſneſs, worrying and 'deſtroying the young geeſe and goſlings.' In another part of his valuable work, Mr Willoughby tells us, 'that he has been aſſured 'by credible perſons, that a gooſe will live a hundred years or 'more *.' In man and quadrupeds, the duration of life bears ſome proportion to the times of their growth. But, in birds, their growth, and their powers of reproduction, are more rapid, though they live proportionally longer. Some ſpecies of birds, as all the gallinaceous tribes, can make uſe of their limbs the moment they iſſue from the ſhell; and, in a month or five weeks after, they can likewiſe employ their wings. A dung-hill cock has the capacity of engendering at the age of four months, but does not acquire his full growth in leſs than a year. The ſmaller birds are perfect in four or five months. They grow more rapidly, and produce much ſooner than quadrupeds, and yet they live proportionally much longer. In man and quadrupeds, the duration of life is about ſix or ſeven times more than that of their growth. According to this rule, a cock or a parrot, who arrive at their full growth and powers in one year, ſhould not live above ſix or ſeven. But Nature knows none of our rules. She accommodates her conduct, not to our ſhallow, and often preſumptuous concluſions, but to the preſervation of ſpecies, and to the ſupport and general balance of the great ſyſtem of animated beings. Ravens, though capable of providing for themſelves in leſs than a year, ſometimes have their lives protracted more than a century. The Count de Buffon informs us, that, in ſeveral places of France, ravens have been known to arrive at this extraordinary age, and that,

* Ornithology, page 256.

that, at all times, and in all countries, they have been efteemed birds of great longevity *.

'Eagles,' fays Mr Pennant, 'are remarkable for their longevity, 'and for their power of fuftaining a long abftinence from food. A 'golden eagle, which has now been nine years in the poffeffion of 'Owen Holland, Efq; of Conway, lived thirty-two years with the 'gentleman who made him a prefent of it; but what its age was 'when the latter received it from Ireland is unknown. The fame 'bird alfo furnifhes a proof of the truth of the other remark, ha-'ving once, through the neglect of fervants, endured hunger for 'twenty-one days, without any fuftenance whatfoever †.' The pelican that was kept at Mechlin in Brabant during the reign of the Emperor Maximilian, was believed to be eighty years of age. 'What is reported of the age of eagles and ravens,' fays Mr Willoughby, 'although it exceeds all belief, yet doth it evince that 'thofe birds are very long-lived ‡.' Pigeons have been known to live from twenty to twenty-two years. Even the fmaller birds live very long in proportion to the time of their growth and the fize of their bodies. Linnets, gold-finches, &c. often live in cages fifteen, twenty, and even twenty-three years.

Fifhes, whofe bones are more cartilaginous than thofe of men and quadrupeds, are long of acquiring their utmoft growth, and many of them live to great ages. Gefner gives an inftance of a carp in Germany which he knew to be one hundred years old ‖. Buffon informs us, that, in the Count Maurepa's ponds, he had feen carps of one hundred and fifty years of age, and that the fact was attefted

* Hift. Nat. des Oifeaux, tom. 3. pag. 32.

† Britifh Zoology, vol. 1. 8vo edit. page 123.

‡ Ornithology, page 14.

‖ Gefner de Pifc. pag. 312.

in the moſt ſatisfactory manner. He even mentions one which he ſuppoſed to be two hundred years old *. Two methods have been deviſed for aſcertaining the age of fiſhes, namely, by the circles of the ſcales, and by a tranſverſe ſection of the back-bone. When a ſcale of a fiſh is examined by the microſcope, it is found to conſiſt of a number of circles within one another, reſembling, in ſome meaſure, thoſe rings that appear on the tranſverſe ſections of trees, by which their ages are computed. In the ſame manner, the ages of fiſhes may be aſcertained by the number of circles on their ſcales, reckoning for each ring one year of the animal's exiſtence. The ages of Buffon's carps were chiefly determined by the circles on their ſcales. The age of fiſhes that want ſcales, as the ſkate and ray-kind, may be pretty exactly known by ſeparating the joints of the back-bone, and obſerving minutely the number of rings which the ſurface exhibits. Both of theſe methods may be liable to deception; but they are the only natural ones which have hitherto been diſcovered. The longevity of fiſhes has been aſcribed to ſeveral cauſes. The element in which they live is more uniform, and leſs ſubject to accidental changes than the air of our atmoſphere. Their bones, which are more of a cartilaginous nature than thoſe of land animals, admit of indefinite extenſion; of courſe, their bodies, inſtead of ſuffering the rigidity of age at an early period, which is the natural cauſe of death, continue to grow much longer than thoſe of moſt land-animals.

As to the age of *Reptiles*, probably from the unintereſting nature of the animals, we have very little information. But two letters of J. Arſcott, Eſq; of Tehott in Devonſhire, concerning the longevity of a *toad*, deſerve ſome notice. Theſe letters were addreſſed to Dr Milles, Dean of Exeter, and by him communicated to Mr Pennant in

* Epoques de la Nature, pag. 181.

in the year 1768: 'It would give me the greateſt pleaſure,' ſays Mr Arſcott, 'to be able to inform you of any particulars worthy Mr 'Pennant's notice, concerning the toad who lived ſo many years 'with us, and was ſo great a favourite.—It had frequented ſome 'ſteps before the hall-door ſome years before my acquaintance com-'menced with it, and had been admired by my father for its ſize, '(which was of the largeſt I ever met with), who conſtantly paid it 'a viſit every evening. I knew it myſelf above *thirty* years, and, 'by conſtantly feeding it, brought it to be ſo tame, that it always 'came to the candle, and looked up, as if expecting to be taken up 'and brought upon the table, where I always fed it with inſects of 'all ſorts.—You may imagine that a toad, generally deteſted, (al-'though one of the moſt inoffenſive of all animals), ſo much taken 'notice of and befriended, excited the curioſity of all comers to the 'houſe, who all deſired to ſee it fed; ſo that even ladies ſo far con-'quered the horrors inſtilled into them by nurſes, as to deſire to ſee 'it *.' In the ſecond letter, Mr Arſcott remarks, 'I cannot ſay 'how long my father had been acquainted with the toad before I 'knew it; but, when I was firſt acquainted with it, he uſed to men-'tion it as the old toad I have known ſo many years; I can anſwer 'for *thirty-ſix* years †.'—'In reſpect to its end, had it not been for 'a tame raven, I make no doubt but it would have been now living, 'who one day, ſeeing it at the mouth of its hole, pulled it out, and, 'though I reſcued it, pulled out one eye, and hurt it ſo, that, not-'withſtanding its living a twelvemonth, it never enjoyed itſelf, and 'had a difficulty in taking its food, miſſing the mark for want of 'its eye. Before that accident it had all the appearance of perfect 'health ‡.'

* Pennant's Britiſh Zoology, vol. 3. pag. 323.

† Ibid. pag. 326.

‡ Ibid. pag. 331.

Moſt *Inſects*, eſpecially after their laſt transformation, are ſhort-lived. But the ſpecies are continually ſupported by their wonderful fecundity. Thoſe animals whoſe parts require a long time of hardening and expanding are endowed with a proportional degree of longevity. Inſects grow, and their bodies harden, more quickly than thoſe of larger animals. Many of them complete their growth in a few weeks, and even in a few days. The duration of their exiſtence is accordingly limited to very ſhort periods. Some ſpecies of flies lie in a torpid ſtate during the winter, and revive when the heat of ſpring or ſummer returns. The ephemeron flies, of which there are ſeveral kinds, ſeldom live above one day, or one hour, after their transformation. But, to continue the ſpecies, Nature has taken care that myriads of males and females ſhould be transformed nearly at the ſame inſtant. Were it otherwiſe, the males and females could have no opportunity of meeting, and the ſpecies would ſoon be extinguiſhed. Other kinds are transformed more irregularly, and live ſeveral days. Here the wiſdom of Nature is conſpicuous: She prolongues the exiſtence of theſe animals for no other purpoſe but to allow the individuals of both ſexes to meet and multiply the ſpecies. Bees, and flies of all kinds, after lying long in water, and having every appearance of death, revive by the application of a gentle heat, or by covering their bodies with aſhes, chalk, or ſand, which abſorb the ſuperfluous moiſture from their pores. Reaumur made many experiments upon the reviviſcence of drowned bees. He found, that, after being immerſed in water for nine hours, ſome of them returned to life; but he acknowledges that many of them, in the fourth part of this time, were actually dead, and that neither heat, nor the application of abſorbent powders, could reſtore them to life. Analogical reaſoning is often deceitful, but it frequently leads to uſeful truths. As flies of all kinds, after immerſion in water, and exhibiting every mark of actual death, can be reſtored to life by covering their bodies with any abſorbent ſubſtance, without the aſſiſtance of a heat ſuperior to that of the common atmoſphere, might not the ordinary methods employed for the recovery of drowned perſons be aſſiſted by the application of warm aſhes or chalk? The ſtructure of a fly and that of a man, it is allowed, are very different. But, in deſperate caſes, when every other method fails, no fact ſhould be overlooked, and no analogy deſpiſed.

Plants differ as much in the periods of their exiſtence as animals. Many plants periſh yearly; others are biennial, triennial, &c. But the longevity and magnitude of particular trees are prodigious. We are informed by Mr Evelyn, that, in the bodies of ſome Engliſh oaks, when cut tranſverſely, three, and even four, hundred rings of wood have been diſtinguiſhed. A ring of wood is added annually to the trunks of trees; and, by counting the rings, the age of any tree may be pretty exactly aſcertained *. With regard to the magnitude of oaks, ſome of them are huge maſſes. Dr Hunter, in his Notes upon Evelyn's Sylva, remarks, that none 'of the oaks mentioned by Mr Evelyn bear any proportion to one now growing at 'Cowthorpe, near Wetherby, upon an eſtate belonging to the Right 'Hon. Lady Stourton. The dimenſions are almoſt incredible. Within three feet of the ſurface, it meaſures ſixteen yards, and, cloſe by 'the ground, twenty-ſix yards. Its height, in its preſent and ruinous ſtate, (1776), is about eighty-five feet, and its principal limb 'extends ſixteen yards from the bole.—When compared to this, all 'other trees are but *children* of the foreſt †.'

From the facts which have been enumerated, it appears, that all animals, as well as vegetables, have ſtated periods of exiſtence, and that their diſſolution is uniformly accompliſhed by a gradual hardening

* See Evelyn's Sylva, page 505.

† Ibid. page 500.

ing and deficcation of their conftituent parts. No art, no medicine, can retard the operations of Nature. It is, therefore, the wifdom and the duty of every human being to fail down the irrefiftible current of Nature with all poffible tranquillity and refignation. Life, whether fhort or long, whether fortunate or unfortunate, when the fatal period arrives, is of little confequence to the individual. Society, knowledge, virtue, and benevolence, are our only rational enjoyments, and ought to be cultivated with diligence.

With regard to animals in general, the actual duration of their lives is very different. But the comparative fhortnefs or length of life, in particular animals, probably depends on the quicknefs or flownefs of the ideas which pafs in their minds, or of the impreffions made upon their fenfes. A rapid fucceffion of ideas or impreffions makes time feem proportionally long. There is likewife a connection between the quicknefs and flownefs of ideas, and the circulation of the blood. A man whofe pulfe is flow and fluggifh, is generally dull and phlegmatic. Raife this fame man's pulfe with wine, or any other exhilarating ftimulus, and you immediately quicken his fenfations, as well as the train of his ideas. In all young animals, the circulation of the blood is much more rapid than after they have acquired their full growth. Young animals, accordingly, are frolickfome, vivacious, and happy. But, when their growth is completed, the motion of the blood is flower, and their manners, of courfe, are more fedate, gloomy, and penfive. Another circumftance merits attention. The circulation of the blood is flower or quicker in proportion to the magnitude of animals. In large animals, fuch as man and quadrupeds, the blood moves flowly, and the fucceffion of their ideas is proportionally flow. In the more minute kinds, as mice, fmall birds, fquirrels, &c. the circulation is fo rapid that the pulfes of their arteries cannot be counted. Now, animals of this defcription aftonifh us with the quicknefs of their movements, the vivacity

of

of their manners, and the extreme chearfulnefs of their difpofitions.

Reaumur, Condillac, and many other philofophers, confider duration as a relative idea, depending on a train of confcious perception and fentiment. It is certain that the natural meafure of time depends folely on the fucceffion of our ideas. Were it poffible for the mind to be totally occupied with a fingle idea for a day, a week, or a month, thefe portions of time would appear to be nothing more than fo many inftants. Hence a philofopher often lives as long in one day, as a clown or a favage does in a week or a month fpent in mental inactivity and want of thought.

This fubject fhall be concluded with a fingle remark: If it be true, and we are certain that it is fo in part, that animals of every fpecies, whatever be the real duration of their lives, from a flow or rapid fucceffion of ideas, and perhaps from the comparative intenfity of their enjoyments, live equally long, and enjoy an equal portion of individual happinefs, it opens a wonderful view of the great benevolence of Nature. To ftore every portion of this globe with animal life, She has amply peopled the earth, the air, and the waters. The multifarious inhabitants of thefe elements, as to the actual duration of their lives, are extremely diverfified. But, by variation of forms, of magnitude, of rapidity of ideas, of intenfity of pleafures, and, perhaps, of many other circumftances, She has conferred upon the whole nearly an equal portion of happinefs.

CHAPTER XXII.

Of the Progreſſive Scale or Chain of Beings in the Univerſe.

TO men of obſervation and reflection, it is apparent, that all the beings on this earth, whether animals or vegetables, have a mutual connection and a mutual dependence on each other. There is a graduated ſcale or chain of exiſtence, not a link of which, however ſeemingly inſignificant, could be broken without affecting the whole. Superficial men, or, which is the ſame thing, men who avoid the trouble of ſerious thinking, wonder at the deſign of producing certain inſects and reptiles. But they do not conſider that the annihilation of any one of theſe ſpecies, though ſome of them are inconvenient, and even noxious to man, would make a blank in Nature, and prove deſtructive to other ſpecies who feed upon them. Theſe, in their turn, would be the cauſe of deſtroying other ſpecies, and the ſyſtem of devaſtation would gradually proceed, till man himſelf would be extirpated, and leave this earth deſtitute of all animation.

In the chain of animals, man is unqueſtionably the chief or capital link, and from him all the other links deſcend by almoſt imperceptible gradations. As a highly rational animal, improved with ſcience and arts, he is, in ſome meaſure, related to beings of a ſupe-

rior

rior order, wherever they exiſt. By contemplating the works of Nature, he even riſes to ſome faint ideas of her great Author. Why, it has been aſked, are not men endowed with the capacity and powers of angels? beings of whom we have not even a conception. With the ſame propriety, it may be aſked, Why have not beaſts the mental powers of men? Queſtions of this kind are the reſults of ignorance, which is always petulant and preſumptuous. Every creature is perfect, according to its deſtination. Raiſe or depreſs any order of beings, the whole ſyſtem, of courſe, will be deranged, and a new world would be neceſſary to contain and ſupport them. Particular orders of beings ſhould not be conſidered ſeparately, but by the rank they hold in the general ſyſtem. From man to the minuteſt animalcule which can be diſcovered by the microſcope, the chaſm ſeems to be infinite: But that chaſm is actually filled up with ſentient beings, of which the lines of diſcrimination are almoſt imperceptible. All of them poſſeſs degrees of perfection or of excellence proportioned to their ſtation in the univerſe. Even among mankind, which is a particular ſpecies, the ſcale of intellect is very extenſive. What a difference between an enlightened philoſopher and a brutal Hottentot? Still, however, Nature obſerves, for the wiſeſt purpoſes, her uniform plan of graduation. In the human ſpecies, the degrees of intelligence are extremely varied. Were all men philoſophers, the buſineſs of life could not be executed, and neither ſociety, nor even the ſpecies, could long exiſt. Induſtry, various degrees of knowledge, different diſpoſitions, and different talents, are great bonds of ſociety. The Gentoos, from certain political and religious inſtitutions, have formed their people into different caſts or ranks, out of which their poſterity can never emerge. To us, ſuch inſtitutions appear to be tyrannical, and reſtraints on the natural liberty of man. In ſome reſpects they are ſo: But they ſeem to have been originally reſults of wiſdom and obſervation; for, independently of all political inſtitutions, Nature herſelf has formed the human ſpecies into caſts or ranks. To ſome ſhe gives ſuperior genius and mental abilities; and, even of theſe, the views, the purſuits, and the taſtes, are moſt wonderfully diverſified.

In the talents and qualities of quadrupeds of the ſame ſpecies, there are often remarkable differences. Theſe differences are conſpicuous in the various races of horſes, dogs, &c. Even among the ſame races, ſome are bold, ſprightly, and ſagacious. Others are comparatively timid, phlegmatic, and dull.

Our knowledge of the chain of intellectual and corporeal beings is very imperfect; but what we do know gives us exalted ideas of that variety and progreſſion which reign in the univerſe. A thick cloud prevents us from recogniſing the moſt beautiful and magnificent parts of this immenſe chain of being. We ſhall endeavour, however, to point out a few of the more obvious links of that chain, which falls under our own limited obſervation.

Man, even by his external qualities, ſtands at the head of this world. His relations are more extenſive, and his form more advantageous, than thoſe of any other animal. His intellectual powers, when improved by ſociety and ſcience, raiſe him ſo high, that, if no degrees of excellence exiſted among his own ſpecies, he would leave a great void in the chain of being. Were we to conſider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the ſame family, we ſhould imagine that the ſpecies of men were as various as the number of individuals. How many gradations may be traced between a ſtupid Huron, or a Hottentot, and a profound philoſopher? Here the diſtance is immenſe; but Nature has occupied the whole by almoſt infinite ſhades of diſcrimination.

In defcending the fcale of animation, the next ftep, it is humiliating to remark, is very fhort. Man, in his loweft condition, is evidently linked, both in the form of his body and the capacity of his mind, to the large and fmall orang-outangs. Thefe again, by another flight gradation, are connected to the apes, who, like the former, have no tails. It is wonderful that Linnaeus, and many other naturalifts, fhould have overlooked this gradation in the fcale of animals, and maintained, that the ifland of Nicobar, and fome other parts of the Eaft Indies, were inhabited by tailed men. Before thofe animals whofe external figure has the greateft refemblance to that of man, are ornamented, or rather deformed, with tails, there are feveral fhades of difcrimination. The larger and fmaller orang-outangs, which are real brutes, have no tails. Neither are the numerous tribes of apes furnifhed with this appendage. But the believers in tailed men gravely tell us, that there is nothing furprifing in this phenomenon, becaufe a tail is only a prolongation of the *os coccygis*, which is the termination of the back-bone. They confider not, however, that, inftead of accounting for the exiftence of tailed men, they do nothing more than fubftitute a learned circumlocution for the fimple word *tail*. It is here worthy of remark, that a philofopher, who has paid little attention to natural hiftory, is perpetually liable to be deceived; and that a naturalift, I mean a nomenclator, without philofophy, though he may be ufeful by mechanically marking diftinctions, is incapable of enriching our minds with general ideas. A proper mixture of the two is beft calculated to produce a real philofopher. From the orang-outangs and apes to the baboons, the interval is hardly perceptible. The true apes have no tails, and thofe of the baboons are very fhort. The monkeys, who form the next link, have long tails, and terminate this partial chain of imitative animals, which have fuch a deteftable refemblance to the human frame and manners.

When examining the characters by which beings are diſtinguiſh-able from each other, we perceive that ſome of them are more ge-neral, and include a greater variety than others. From this cir-cumſtance all our diſtributions into claſſes, orders, genera, and ſpe-cies, are derived. Between two claſſes, or two genera, however, Nature always exhibits intermediate productions ſo cloſely allied, that it is extremely difficult to aſcertain to which of them they be-long. The polypus, which multiplies by ſhoots, or by ſections, from its body, connects the animal to the vegetable kingdom. Thoſe worms which lodge in tubes compoſed of ſand, ſeem to link the in-ſects to the ſhell and cruſtaceous animals. Shell-animals and cruſta-ceous inſects make alſo a near approach to each other. Both of them have their muſcles and inſtruments of motion attached to ex-ternal inſtead of internal bones. From reptiles, the degrees of per-fection in animal life and powers move forward in a gradual but perceptible manner. The number of their organs of ſenſe, and the general conformation of their bodies, begin to have a greater ana-logy to the ſtructure of thoſe animals which we are accuſtomed to conſider as belonging to the more perfect kinds. The ſnake, by its form, its movements, and its mode of living, is evidently con-nected with the eel and the water-ſerpent. Like reptiles, moſt fiſh-es are covered with ſcales, the colours and variety of which often enable us to diſtinguiſh one ſpecies from another. The forms of fiſhes are exceedingly various. Some are long and ſlender; others are broad and contracted. Some fiſhes are flat, others cylindrical, triangular, ſquare, circular, &c. The fins of fiſhes, from the me-dium in which they live, are analogous to the wings of birds. Like thoſe of reptiles, the heads of fiſhes are immediately connected to their bodies, without the intervention of necks. The flying fiſhes, whoſe fins reſemble the wings of bats, form one link which unites the fiſhes to the feathered tribes. Aquatic birds ſucceed, by a gentle gradation, the flying fiſhes.

In

In tracing the gradations from fishes to quadrupeds, the transition is almost imperceptible. The sea-lion, the morse, all the cetaceous tribes, the crocodile, the turtle, the seals, have such a resemblance, both in their external and internal structure, to terrestrial quadrupeds, that some naturalists, in their methodical distributions, have ranked them under the same class of animals. The bats and the flying squirrels, who traverse the air by means of membranous instead of feathered wings, evidently connect quadrupeds with birds. The ostrich, the cassowary, and the dodo, who rather run than fly, form another link between the quadruped and the bird.

All the substances we recognise on this earth may be divided into organised and animated, organised and inanimated, and unorganised, or brute matter. The whole of these possess degrees of perfection, of excellence, or of relative utility, proportioned to their stations or ranks in the universe. Change these stations or ranks, and another world would be necessary to contain and support them. Beings must not be contemplated individually, but by their rank, and the relations they have to the constituent parts of the general system of Nature. Certain results of their natures we consider as evils. Destroy these evils, and you annihilate the beings who complain of them. The reciprocal action of the solids and fluids constitutes life, and the continuation of this action is the natural cause of death. Immortality on this earth, therefore, presupposes another system; for our planet has no relation to immortal beings. Every animal, and every plant, rises, by gentle gradations, from an embryo, or gelatinous state, to a certain degree of perfection exactly proportioned to their several orders. An assemblage of all the orders of relative perfection constitutes the absolute perfection of the whole. All the planets of this system gravitate toward the sun and toward each other. Our system gra-

vitates

vitates toward other fyftems, and they to ours. Thus the whole univerfe is linked together by a gradual and almoft imperceptible chain of exiftences both animated and inanimated. Were there no other argument in favour of the UNITY of DEITY, this uniformity of defign, this graduated concatenation of beings, which appears not only from this chapter, but from many other parts of the book, feems to be perfectly irrefragable.

In contemplating Man, as at the head of thofe animals with which we are acquainted, a thought occurred, that no fentient being, whofe mental powers were greatly fuperior, could poffibly live and be happy in this world. If fuch a being really exifted, his mifery would be extreme. With fenfes more delicate and refined; with perceptions more acute and penetrating; with a tafte fo exquifite that the objects around him could by no means gratify it; obliged to feed upon nourifhment too grofs for his frame; he muft be born only to be miferable, and the continuation of his exiftence would be utterly impoffible. Even in our prefent condition, the famenefs and infipidity of objects and purfuits, the futility of pleafure, and the infinite fources of excruciating pain, are fupported with great difficulty by cultivated and refined minds. Increafe our fenfibilities, continue the fame objects and fituation, and no man could bear to live.—Let man, therefore, be contented. His ftation in the univerfal fcale of Nature is fixed by Wifdom. Let him contemplate and admire the works of his Creator; let him fill up his rank with dignity, and confider every partial evil as a caufe or an effect of general good.—This is the whole duty of man.

THE END.

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