A

SURVEY

OF THE

WISDOM OF GOD

IN

The *CREATION*:

OR, A

COMPENDIUM

OF

NATURAL PHILOSOPHY:

IN FIVE VOLUMES.

THE THIRD EDITION, ENLARGED.

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VOL. IV.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then?

MILTON.

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PART the FIFTH.

CONTINUED.

CHAP. III.

Of the Properties that are common to all Bodies, and of the Elements of Natural Bodies.

1. *Of Extension.*
2. *Of a Vacuum.*
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5. *Of Motion and Rest.*
6. *Of the laws of Motion.*
7. *Of the Aristotelic Elements.*
8. *Of the principles of the Chymists.*
9. *Objections to them.*
10. *What is the primary Element of all things.*

1. HAVING spoken of the particular species of Bodies, it remains only to speak of Bodies in general. And it may be observed of them all, that they are extended, solid, divisible,

 figured,

figured, and capable of motion. We cannot conceive any body that is not *extended*, or compofed of feveral parts. And yet we cannot affirm, that the *effence* of Body confifts in this alone.

2. For there may be extenfion without body, which is ufually termed *fpace* or a *vacuum*. Thefe are widely different from each other. Body is divifible and feparable into parts, and confequently capable of motion; none of which can be faid of mere fpace. And that there is empty fpace is clear from hence. That if all were full, there could be no motion in the world. For in order to this it is requifite that each particle leave its place empty for another to fill. It is faid indeed, this need not be, becaufe all motion is circular, fo that in every motion of whatever kind, each part of the body moved, fucceeds another. But this is abfolutely contrary to matter of fact. We fee with our eyes, that all motion is not circular. And if not, then there muft be empty fpace, or there could be no motion at all.

3. Another property of Body is *Solidity*, whereby it refifts another body, moving it out of its place. Not much different from this, is *Impenetrability*, whereby a body excludes another from the place where it is. Solidity is not the fame with *hardnefs*, the former belonging to all, the latter to fome bodies only. Hardnefs confifts in the firm cohefion of the parts, fo as not eafily to be feparated. As the Solidity of bodies flows from the intrinfic nature of matter, it is vain to affign as the caufe of it, either the figure or reft of the parts, or the preffure of the air, or of fome fubtle matter. By thefe folutions we do not at all explain

explain the thing, but only intangle ourſelves in freſh difficulties.

4. *Diviſibility* likewiſe belongs to all bodies. For ſince no body can be conceived that is not extended, and extenſion ſuppoſes parts, it follows that every body, however ſmall, is diviſible: perhaps not by the art of man, but in its own nature. Nor is it any objection, that our underſtanding cannot comprehend *infinite Diviſibility*. It cannot: nor can it comprehend infinite number: or indeed infinites of any kind.

It is true, there is no ſuch thing, ſtrictly ſpeaking, as parts infinitely ſmall. Yet the ſmallneſs of the particles of ſeveral bodies, is ſuch as vaſtly ſurpaſſes our conception. And there are innumerable inſtances in nature of ſuch parts actually ſeparated from each other.

Mr. Boyle gives us ſeveral inſtances of this. He ſpeaks of a ſilken thread, three hundred yards long, that weighed but two grains and an half. Fifty ſquare inches of leaf-gold weighed but one grain. Now if the length of an inch be divided into two hundred parts, the eye may diſtinguiſh them all. Therefore there are in one ſquare inch forty thouſand viſible parts, and in one grain of leaf-gold, two millions of ſuch parts: which viſible parts no one will deny to be farther diviſible. In odoriferous bodies, we may diſcern a ſtill greater ſubtlety of parts, yea, of parts actually ſeparated from each other. Several bodies ſcarce loſe any thing of their weight in a long time, and yet continually fill a large ſpace with odoriferous particles. Several animals are but juſt viſible with the fineſt microſcope. And yet theſe have all the parts neceſſary for life, as blood and other juices. How wonderful muſt the ſubtlety of the parts be, whereof thoſe fluids are compoſed. And hence the following ſtrange theorem is deduced and demonſtrated by Dr. Keil. "Any particle of matter, how ſmall ſoever, and any finite ſpace, how large ſoever, being given, it is poſſible for that particle to be diffuſed through all that ſpace, and to fill it in ſuch a manner, that there ſhall be no pore in it, whoſe diameter ſhall exceed any given line."

5. The laſt general property of matter is *Motion* and *Reſt*. For it is plain, all matter is either at Reſt or in Motion. God is the firſt and univerſal cauſe of Motion, as well as of all things. The immediate cauſe of it, is either matter or ſpirit. It is beyond doubt, that a body moved, communicates its motion to another, though in its own nature it be purely paſſive. Nor can we reaſonably deny that a ſpirit is able to move matter, although the manner of its doing this we cannot comprehend.

6. All the laws of Motion may be reduced to three. 1. Every moving body is moved by another: 2. Every moving body communicates its motion to any body it meets: 3. Every moving body continues in motion, till it communicates that motion to another. While theſe laws remain in force, and concur in producing various effects; thoſe effects are termed natural. When any of theſe laws is ſuſpended, this is properly a miracle.

7. As

7. As the elements or firſt ſtamina of bodies are too ſmall to be diſcerned by any of our ſenſes, we can only form conjectures concerning them. The moſt probable conjectures are theſe. Empedocles, and Ariſtotle from him, ſuppoſed, there are four elements, *fire*, *air*, *water* and *earth*. And indeed this diviſion ſeems to be grounded on the nature of things: for there is no doubt but at the creation of this globe, the confuſed maſs was ſeparated into four parts, the heavieſt of which conſtituted the *earth*, the particles next in weight the *water*, the third, lighter ſtill, *air*, and the lighteſt of all, *fire*, otherwiſe termed *ether*. And it is manifeſt, all bodies known to us, are reducible to one or more of theſe. Every thing corporeal is either earth, air, water or fire, or compounded of them. So that after all the diſquiſitions of two or three thouſand years, this eaſy, plain, natural account of the elements, is not likely to be amended: it being a certain fact, that of theſe do all bodies conſiſt.

8. The Chymiſts have taken another way, endeavouring to trace the principle of bodies, not by the ordinary uſe of their ſenſes, nor by reaſoning, but from experiments made by fire. And by this means they make five elements. For whatever is diſtilled, firſt emits a ſapid and ſpirituous vapour, which is by cold condenſed into a liquor: and this they term *Mercury*: then an inſipid liquor, which they call *phlegm*: afterward an acid liquor, which is alſo termed *Mercury*. A thicker and oily liquor comes next, which becauſe eaſily inflammable, is ſtiled *Sulphur*. The *Salt* which is afterwards found is their fourth element, the inſipid *Earth*, which is left, the fifth.

9. But not to insist, that all bodies are not resolvible into these principles, it is utterly uncertain, whether fire does not alter the natural qualities of bodies, and introduce other qualities into them, which they had not before. Besides some of these are not simple elements. They are compounded of others, oils and salts in particular. Therefore neither are all those oils and salts of one sort, but as various as the bodies from which they are extracted. In truth, these are at most the constituent parts of two of the Aristotelic elements, namely water and earth: but the two others, air and fire, are quite omitted in their account.

10. Perhaps one might rather term *Matter* itself with its general properties, the first and most simple element, out of which all things are compounded. But the particles of this are not fit to compose the immediate stamina of larger bodies, till they combine together into oils, salts, and juices of various kinds. And hence arise those principles of the Chymists, of which most bodies are compounded: although still they are only secondary elements, as being themselves compounded. Indeed it seems probable, God in the beginning formed Matter in solid, impenetrable, moveable particles, of such sizes and figures as most conduced to the end for which he formed them: and that these primitive bodies are incomparably harder than any porous bodies compounded of them: even so hard as never to wear out, no natural power being able to divide them. And thus remaining entire, they compose bodies of the same nature and texture in all ages: whereas should these wear away, or break in pieces, the

nature

nature of things depending on them would be changed. Nor would water and earth, composed of broken, worn-out particles, be the same as they were at the beginning. But they are the same in all ages: and the changes of things do not imply any change in those original particles, but only various associations and separations of them. Nor do compound bodies ever break in the middle of solid particles, but where those particles are joined together, and only touch in a few points.

CHAP. IV.

Of thoſe things wherein Natural Bodies differ.

1. HAVING conſidered wherein Natural Bodies agree, we come now to conſider, the particular Properties wherein they diſagree, and whereby they are diſtinguiſhed from each other. Thoſe of them, which are perceived by our outward ſenſes, are divided accordingly into various claſſes, as they affect the ſenſe of ſight, of hearing, of taſting, of ſmelling, or of feeling.

2. *Light* ſeems to be one of the moſt ſubtle bodies in the univerſe. The grand reſervoir thereof is the ſun: but it is likewiſe emitted by many other bodies, and by almoſt all, when they are on fire. When it falls on any body which it cannot paſs

pafs through, and fo is beat back, it is faid to be *reflected*. But when it paffes from one *tranfparent* body into another, which is either rarer or denfer, it moves obliquely, its rays being bent, and is faid to be *refracted*. When it paffes through a body in ftrait lines, it is faid to be *tranfmitted*. Thofe which emit the light are termed *lucid* bodies; thofe which reflect it, *opake*.

The particles of Light, minute as they are, are attracted by thofe of other bodies. Hence in their paffage near the edges of bodies, whether opake or tranfparent, they are diverted from the right lines, and reflected towards thofe bodies. This action of bodies on light exerts itfelf at fome diftance, but increafes as the diftance is diminifhed: as appears in the paffage of a ray between the edges of two thin plates, at different apertures in which it is peculiar, that the attraction of one edge is increafed, as the other is brought nearer it. The rays of Light paffing out of glafs into a vacuum, are not only inflected toward the glafs, but if they fall too obliquely, they will revert back to the glafs, and be totally reflected. This reflection cannot be owing to any refiftance of the vacuum, but merely to the attracting power of the glafs. This appears farther from hence: if you wet the pofterior furface of the glafs, the rays, which would otherwife have been reflected, will pafs into and through that liquor: which fhews that the rays are not reflected, till they come to that pofterior furface of the glafs; nor even till they begin to go out of it. For if at their going out, they fall into any liquor, they are not reflected, but perfift in their courfe, the attraction of the liquor counterbalancing that of the glafs.

From this mutual attraction between the particles of light and other bodies, arises the reflection and refraction of light. The determination of any moving body is changed, by the interposal of another body. Thus light meeting any solid body, is turned out of its way, and reflected: but with this peculiar circumstance; it is not reflected from the body itself, but by something diffused over the surface of that body, before it touches it. It is the same thing in refraction. The rays refracted come very near the refracting body; yet do not touch it. Those that actually touch solid bodies, adhere to them, and are as it were extinguished and lost.

This entirely agrees with the curious observation of an ingenious writer. " It is common to admire the lustre of the drops of rain, that lie on the leaves of Coleworts and some other vegetables. Upon inspecting them narrowly, I find the lustre rises from a copious reflection of the light, from the flattened parts of its surface, contiguous to the plant. When the drop rolls along a part which has been wetted, it immediately loses all its lustre. The green plant being then seen clearly through it, whereas in the other case it is hardly to be discerned.

From these two observations laid together, we may conclude the drop, when it has the lustre, does not really touch the plant, but hangs in the air at some distance from it, by the force of a repulsive power. For there could not be so copious a reflection of light from its under surface, unless there were a real interval between it and the surface of the plant.

Now if that surface were perfectly smooth, the under surface of the drop would be so likewise, and would therefore reflect the image of the illuminating body, like a piece of polished silver. But

But as it is rough, the under surface of the drop becomes rough likewise; and so reflecting the light copiously in different directions, assumes the colour of unpolished silver."

Again. Rays passing from a more rare into a more dense medium, are turned out of their right line, because more strongly attracted by the denser medium.

Rays of Light differ in respect of refraction, reflection and colour. Those that agree in the first of these, agree in all, and may therefore be termed *homogeneal*. Colours exhibited by them we may call *homogeneal colours*. This being premised, we may observe, 1. That the sun's light consists of rays variously refrangible: 2. The rays variously refrangible, when separated from each other, exhibit different colours: 3. That there are as many simple, homogeneal colours, as there are degrees of refrangibility: 4. A composition of all the simple colours, is requisite to constitute whiteness: 5. The rays of Light do not act upon one another, in passing through the same medium: 6. Neither do they thereby suffer any refraction: 7. The sun's rays contain all homogeneal colours, which may therefore be called *primitive*.

As some rays of Light are less than others, so they are more refrangible. Those which are most refrangible, constitute *violet* colour: that is the smallest rays excite the most languid colour. Those which are largest and so least refrangible, constitue *red*, the most vivid colour. The other rays excite intermediate sensations, according to their respective size and refrangibility.

Bodies

Bodies reflect, instead of transmitting Light, that is, are opake, not transparent, not for want of pores; but either because of the unequal density of their parts, or the magnitude of their pores. Either *their* pores are empty, or they are filled with matter of a different kind, whereby the rays are variously refracted and reflected, till they are quite absorbed.

Hence paper and wood are opake, while glass is transparent. For in the confines of parts alike in density (such as those of glass and water) there arises no refraction or reflection, by reason of the equal attraction every way; so that the rays which enter the first surface, pass strait through the body. But in the parts of wood and paper, which are unequal in density, and contain much air in their large pores, the refractions and reflection are very great; so that the rays cannot pass through them, but are bandied about till they are extinguished.

Hence opake bodies become transparent, when their pores are filled with a substance of equal density: as paper dipt in water or oil. And on the contrary, transparent bodies, by emptying their pores, or separating their parts, become opake. Thus salts and wet paper become opake by drying, glass by pulverizing. Yea, water itself, if beat into froth, loses its transparency.

That Light is corporeal, cannot now be doubted, having been proved by a thousand experiments. By reflection and refraction it may be turned more or less out of its way, according to the different densities of the reflecting or refracting medium. Its rays in their progressive motion may be intercepted by the interposal of any opake object.

object. And when this is removed, they proceed again, in the same strait course as before. They may likewise be contracted into a less, or diffused through a larger space, while the quantity of light continues the same, neither increased nor diminished. So in the focus of a burning glass, all the rays which would otherwise pass directly through the glass, are contracted into one bright spot, while the circumambient space, for the breadth of the glass, is deprived of its light, and left shaded. And the action of light thus condensed, is proportional to its quantity, and produces all the effects of the most intense fire, yea, such as no culinary fire will produce. Whence it is plain, that fire and light are essentially the same, and that fire is only condensed light.

The materiality of light is farther confirmed by its motion. For vision is propagated through this medium successively, as sound is through air. This has been demonstrated from the eclipses of Jupiter's satellites. For the Satellite having been hid behind the planet, it requires a certain time, after it emerges, before its light can reach the eye, namely seven minutes and an half: which is a motion six hundred thousand times swifter than that of sound through the air.

The quantity of Elementary Light, is *cæteris paribus*, every where the same at the same distance from the sun. But its action is more or less intense, as the rays are more direct or oblique. These are in a continual vibrating motion, going and returning to and from the resisting medium, in exceeding short and imperceptible intervals, which makes the element seem to be at perfect rest.

reſt. All the rays are refracted and reflected alternately; ſo that the ſame incident ray, which is refracted at one interval, is reflected at the next. This is viſible in tranſparent mediums, where the rays fall upon glaſs, water and the like. But in opake bodies, though the fact is the ſame, it is not ſo ſenſible. When the rays fall upon glaſs, they are reflected one moment, and tranſmitted the next. And this vibrating motion ſeems to be eſſential to Light, when its rays are put into motion.

In talking of Light and Sound, we are apt to confound the ſenſation with the motion of the medium that excites it. Thus in a deep calm we ſay, There is no air, becauſe we feel none: though there is really the ſame quantity of air in equal ſpace, as if it blew a ſtorm. And ſo in deep darkneſs we ſay, There is no light in the room: although there is ſuppoſed to be as much light there, as there was at noon-day. Only its rays are quieſcent, and make no impreſſion upon the viſive organs.

Sound is ſaid to move about fourteen miles in a minute, which is performed thus. The ſtroke given by the ſounding body to the contiguous air, is communicated to the next, and ſo on till it reaches the ear.

The oſcillations of the air are required to ſucceed each other with a certain velocity; and in order to render them audible, they muſt not be fewer than thirty in a ſecond of time. But the more frequent theſe ſonorous waves are in a given time, the ſharper is the ſound heard; and the more ſtrongly does

does it affect us; till we come to the most acute of audible sounds, which have 7520 tremors in a second.

Acute sounds are, in general, yielded from bodies that are hard, brittle and violently shook or struck; grave sounds are from the contrary. Cords or other bodies, that yield the same number of vibrations in a given time, are said to be *unison*; as those which make double the number of oscillations in that time, yield a tone that is an octave, or eight notes higher; and other proportions betwixt the number of the vibrations, have different names assigned to them in a musical scale. The shorter cords produce sharper tones, and the reverse in a proportion directly as their lengths; also those, which are more stretched, afford sharper sounds.

The Sound whether acute or grave, strong or weak, is carried through the air about 1038 Paris feet in a second, and that with an uniform velocity, without abating in the larger distances. But a contrary wind, causing the vibrations to extend more slowly, retards the progression of Sound about one-twelfth of its velocity. Density and dryness of the air increase the Sound, as the rarefaction and moisture of the air lessen it. Hence in summer time Sound moves swifter; and in Guinea, it has been observed to pass at the rate of 1398 Parisian feet in one second.

Plutarch says, Deers and horses are of all irrational creatures, the most affected with music. Mr. Playford says the same thing, and adds, "Myself, as I travelled some years since, near Royston, met about twenty stags upon the road, following a bagpipe and violin; which when the

the mufic played, went forward, when it ceafed, they all ftood ftill. And in this manner they were brought from Yorkfhire to Hampton Court. Horfes likewife, lions and elephants are fufceptible of the powers of mufic. So are many dogs, and moft, if not all finging birds." A late author gives a ftranger account ftill.

Monfieur de ———, Captain of the Regiment of Navarre, was confined in prifon fix months. He begged leave of the governor that he might fend for his lute. After four days he was aftonifhed, to fee at the time of his playing, the mice come out of their holes, and the fpiders defcend from their webs, which came and formed a circle round him, to hear him with attention. This at firft fo furprized him, that he left off, on which they all retired quietly into their lodgings. It was fix days before he recovered from his aftonifhment. He then began to play again. They came again, and in ftill increafing numbers, till after a time he found an hundred of them about him.

I faw a very large and fierce lion which was then kept at the Infirmary at Edinburgh, quite tranfported with the found of a bagpipe, and rolling upon its back with the utmoft fatisfaction. I faw likewife the old lion, in the Tower of London liften with the utmoft attention to a German Flute. Meantime a young Tiger leaped up and down inceffantly, till the mufic ceafed. So it may be literally true,

Suetus amphion lenire tigres.

Light is propagated about two hundred thoufand miles in a fecond, after the very fame manner.

ner. The ſun impreſſes the contiguous part or its viſive atmoſphere: (Light ſeems to be the atmoſphere of the ſun, as air is of all opake bodies.) That part impreſſes the next, and ſo on, till it reaches the eye.

All ſenſation is from contact or feeling. And when the object is not in immediate contact with the organ it affects, touches, or impreſſes, by an interpoſed medium. By this means the ſoul perceives or feels the object by the proper organ. And thus, ſeeing is in effect, the feeling of the eye; hearing, the feeling of the ear.

From all our experiments it appears, that the particles of Light are extremely minute. Probably they are the very ſmalleſt and laſt diviſions of matter, which being perfectly ſolid, cannot receive any other form. So minute are they as to paſs freely even through the pores of glaſs, which no other fluid can penetrate.

All other bodies are immerſed in this univerſal fluid, the common medium of all their actions on each other. But amidſt all the changes of compound bodies, all the forms they ſucceſſively put on, this ſimple element remains for ever fixed and immutable.

As to Fire or condenſed Light, all bodies whatever fly or recede from it, in proportion to its denſity: and this ſeems to be its firſt and moſt eſſential property, that no other body can exiſt with it, or bear its immediate action. So far as it prevails, it diſſolves the cloſeſt and ſtrongeſt coheſion of parts in all other bodies, and reduces them into ſo extremely minute particles, that they evaporate

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in air. And herein is an essential difference between this and all other dissolvents in nature, that the substance dissolved cannot unite with the dissolvent, without destroying its action.

When salt dissolves in water, iron in aqua-fortis, or gold in aqua-regia, the substance dissolved is equally diffused through the dissolvent, so as to incorporate with it. But none of the things dissolved by fire, can mix or incorporate with it. They all fly off in vapour: otherwise the fire is presently extinguished.

Elementary Light then, the rays of which when condensed, take the name of Fire, is an element of a peculiar kind, not subject to the mechanical laws of other bodies. Now if we suppose a material fluid, void of gravity, pressure, or any other mechanical power, all gravitating bodies will move through such a fluid, as freely as *in vacuo*.

Elementary Light is a material fluid, void of gravity, pressure or any other mechanical power. When condensed, it is pure, elementary fire, which excludes all other matter out of the same space. Yet it lies in the focus of a burning glass, perfectly still and quiescent. Though it is surrounded by the air, which is a gravitating fluid, pressing equally every way, yet this immechanical element is not at all affected by it, so as to rise or fall in it, or in the least alter its state, either of rest or motion, which must necessarily happen, were it endued with gravity, or the other mechanical properties found in other bodies.

And that the rays of Light, in their progressive motion, do not press, resist, attract, or at all dis-

turb

turb each other, is evident from fact, though they come from every point of space, that can be within the optic angle of the eye. Thus two men standing at a distance, and looking at each other, see one another at the same instant, and that by means of rays, which act in contrary directions, without the least resistance. And any number of other men, standing in any position, may see the same men in the same instant, by rays which cross each other without any interruption, in all possible angles. But in sounds which move through a gravitating, resisting medium, the case is quite different. For a multitude of sounds, from different sonorous bodies, cannot be distinctly heard; particularly, when they come to the ear, in many different directions. For the undulations of the resisting medium, mixing with, and disturbing each other, confuse the sensation, throwing altogether, indiscriminately to the ear. Thus when a multitude of people are all talking together, the ear receives only a confused hum or murmur; whereas the eye can perceive all or any one of them distinctly and without confusion.

Indeed nothing is more sure, than that gravity, pressure, resistance, and all those affections of bodies which are termed their mechanical powers, are not intrinsic or essential to them. For since matter is purely passive, and can only act as it is acted upon, it follows, that the active force or energy, which we observe through the whole material system, must be the effect of some intrinsic, non-essential cause. And such a cause is Light. But then the actions of this can never be mechanically accounted for. How this immechanical fluid acts upon other bodies, and determines

mines their mechanical powers, we can no more explain than how the ſoul acts upon the body, or the mind upon matter. But we are ſure this is not done by weight, preſſure, reſiſtance, or any mechanical property whatever.

"But what are the *general laws of nature?*" They are plainly the rules or principles, by which the Governor and Director of all things, has determined to act. Accordingly what we call *mechaniſm*, is indeed the free agency and continued energy of the Author and Director of nature. All the neceſſary motion of bodies therefore, and all the laws and forces whereby it is communicated and preſerved, are the continued, regular will, choice and agency of the Firſt Cauſe, and inceſſant Mover and Preſerver of the univerſe.

By the help of this admirable, this firſt made, becauſe moſt neceſſary creature, Light, all the animal world is enabled to go here and there, as their occaſions call. We can with pleaſure behold the glorious works of God: we can view the glories of the heavens, the beauties of the flowery fields, the gay attire and exquiſite garniture of many creatures. We can with admiration ſee the great Creator's wonderful art in the parts of animals and vegetables. In a word we can behold the harmony of this lower world, and of the globes above, and ſurvey his exquiſite workmanſhip in every creature.

It is a great inſtance of his providence, that ſo neceſſary as Light is, it is not long in paſſing from place to place. How inconvenient would it be, were the motion of it no ſwifter, than that of the

the ſwifteſt bodies on earth, ſuch as of a bullet out of a great gun, or even of ſound itſelf? Did it move at the rate of the firſt, it would be above thirty two years in coming from the ſun to us, (according to the *common* computation of the ſun's diſtance,) above ſeventeen years at the rate of the ſecond motion. The inconvenience of this would be, its energy would be greatly abated, its rays would be leſs penetrant, and darkneſs would be diſſipated with greater difficulty, eſpecially by the fainter Light of our ſublunary luminous bodies. But paſſing with that prodigious ſwiftneſs, (from the ſun to us in ſeven or eight minutes) we receive with ſecurity and ſpeed the kindly effects of that noble and uſeful creature.

Another thing worthy of conſideration is, the inconceivable extenſion of Light. It is as unlimited as the univerſe itſelf, as is manifeſt from our ſeeing ſome of the moſt diſtant objects, the heavenly bodies, partly with the naked eye, partly with the help of inſtruments. And had we inſtruments of power equal to the extent of light, the luminous bodies in the utmoſt parts of the univerſe, would doubtleſs be viſible too. Hereby we have a ken of thoſe many glorious works of the infinite Creator, which we can improve to ſome of the nobleſt ſciences, and moſt excellent uſes of our own globe.

One ſpecies of *lucid* bodies are termed *Phoſphori:* of which ſome are natural, others ar- artificial. Natural Phoſphori emit Light without any art or preparation. Such are glow-worms, and ſeveral ſorts of ſhining inſects. Such are rotten wood: the eyes, blood, ſcales, fleſh

flesh and feathers of some animals. Diamonds likewise when rubbed emit light, to one who has stayed some time in the dark. But before the diamond is brought into the dark room, it should lie eight or ten seconds in the sun-shine. It will then shine in the dark twelve or thirteen minutes: but its light gradually weakens all the time.

But it is remarkable, that some Diamonds have this property of imbibing the sun's rays, and shining in the dark, and others not, though there is no other discernible difference between them. Nor is there any rule of judging, which diamonds have this property, and which have not. Their brightness, their purity, their size, their shape, contribute nothing to it.

Sulphur and sugar when pounded in the dark, will likewise emit light; as will the backs of horses or cats, when rubbed with the hand, and sea-water, yea and some mineral waters, briskly agitated. But no natural phosphorus shines always, or gives any heat.

Artificial Phosphorus is made chiefly from human Urine. But it may be made from blood, or hair; or indeed from any part of an animal, which yields an oily distillation. It is at first of the consistence of hard wax; but dissolves in all kinds of distilled oil. With solid Phosphorus one may write on paper as with a pencil, and the letters will shine in the dark. A little piece of it rubbed between two papers, takes fire presently. It burns vehemently, and penetrates deeper into the flesh than common fire. It never spoils, if kept in a phial

phial full of water. Liquid Phoſphorus does not keep long. If the face or hands be ſmeared with this, they will ſhine in the dark, yet without any hurt to the ſkin.

If Phoſphorus be put into a long phial, of which three fourths are filled with water, it will frequently ſend up coruſcations, which will pierce through the water, and expand themſelves with great brightneſs in the upper part of the phial.

If we compare this with lightening, we may obſerve, that in this the fire paſſes alternately through the water, ſo in that the flaſhes, which come at intervals, paſs uninterrupted through the moſt denſe clouds and thickeſt rain. But this is uſually in warm weather, not in winter. And it is the ſame with Phoſphorus. It very frequently flaſhes in warm weather, but very rarely in winter.

Again. The flame of Lightning is generally inoffenſive, and does not ſet fire to any thing. In like manner the flaſhes of Phoſporus are harmleſs. and do not ſet fire to the moſt combuſtible matter. But when condenſed Phoſphorus is ſet on fire, it burns terribly. And in the ſame manner lightning when condenſed, burns trees, houſes, or whatever it comes near. Phoſphorus while burning, acts as a corroſive, and when it goes out, forms a menſtruum, which diſſolves gold, iron, and other metals. Lightning melts the ſame ſubſtances.

Another kind of artificial Phoſphorus, is a preparation of the Bononian Stone. This ſtone is of no certain figure, but is ſometimes round, ſometimes oblong, or lenticular. They are uſually as big as an orange, but very light, conſidering their bulk. They are of various colours, ſome aſh-coloured, ſome blue, and ſome almoſt white. When this ſtone is prepared, it receives Light, but in very different degrees, either from the ſun, the moon; common day-light, or a flame. After it has been expoſed a few minutes to any of theſe, it ſhines in the dark like a burning coal, with ſuch a light as is ſufficient to read by, if the letters be held near the ſtone. It does not retain its Light long, but requires often renewing. When well prepared, it will retain this virtue for five or ſix years. It appears to moſt advantage, if brought into a dark room, after being held in the ſun.

3. When the rays of light fall on opake bodies, they are variouſly reflected to our eyes, according as the ſurface of thoſe bodies are variouſly diſpoſed. And hence ariſes our ſenſation of *Colours*. Theſe, as they exiſt in the coloured bodies, are only the diſpoſitions of their ſurface, to reflect ſuch particular ſorts of rays. White bodies reflect all rays every way, without any ſeparation of them. On the contrary, Black bodies imbibe all the rays, and reflect none or very few, whereas *blue*, *yellow*, and *red* bodies, reflect only one particular ſort of rays. The ſmalleſt ſort of rays are ſuppoſed to be blue; the next yellow, the largeſt red.

To be a little more particular. There are eight true *primary* colours, which are red, yellow, green, blue, violet, purple, orange, and indigo. All the reſt are compounded of theſe, and are termed *ſecondary* colours. But the more compound any colour, the leſs vivid it is. And by too much compoſition they may be diluted and weakened 'till they are deſtroyed. The moſt extraordinary compoſition

composition of all is that of *whiteness*. For to this all the primary colours are required, as also, that they be mixed in a certain degree. And hence white is the ordinary Colour of light: light being an assemblage of all colours.

The transmutation of Colours by mixing them together, is not real, but merely apparent. Thus mix blue and yellow powders, and they appear green. But view them with a microscope, and the blue and yellow particles are seen as distinct from each other as before.

To produce *black*, the particles must be less than those which exhibit any other colour. Where they are greater, there is too much light reflected to constitute this Colour. But if there be a little less than forms the indigo, the body appears intensely black.

And hence it appears, why fire and putrefaction turn many substances Black. They divide them into exceeding small particles, which then absorb, instead of reflecting the light. Hence also it appears, why glass ground very elaborately with sand on a copper-plate, makes the sand together with what is worn off from the glass and copper, become very Black: likewise, why Black substances exposed to the sun, are hot sooner than any other. This may partly proceed from the multitude of refractions in a little room, partly from the easy commotion of so small particles, and from their imbibing his rays. Hence also we learn, why Blacks are usually inclined to a bluish colour. Black borders on indigo, and therefore reflects indigo-rays, if any.

To try if black bodies receive heat more than others, Mr. Boyle whited one half of a tile, and blacked the other, and then exposed it to the summer sun. While the white part still remained cool, the black part was grown very hot. For farther ſatisfaction he expoſed to the ſun a tile part of which was blacked, part white, and part of its natural red: and after a while found the black part hot, the red warm, and the white cool.

"I laid on the ſnow, (ſays Dr. Franklin,) little pieces of broad cloth, of divers colours, black, deep blue, light blue, green, purple, red, yellow, white, in a bright ſun-ſhiny morning. In a few hours the black (being warmed moſt) was ſunk loweſt, the dark blue almoſt as low, the light blue not quite ſo much, the other colours leſs as they were lighter, and the white not at all. This was an eaſy and certain way of ſhewing which was heated moſt."

All the *ſecondary* colours of natural bodies proceed from their reflecting two or more ſorts of rays together, and abſorbing the reſt.

Glaſs, chryſtal, diamond, and other tranſparent bodies, loſe their tranſparency, and are white, when reduced to powder: the change of texture cauſing them to reflect the rays which before they tranſmit.

White loaf-ſugar, melted over the fire, without water, firſt turns brown, afterwards black. And a ſingle grain of this tinges a quart of fair water with a beautiful yellow. Violets, roſes, carnations, and moſt flowers loſe their colour, by being long in the open air. And by the ſame means blue eſſential oil of chamomile-flowers changes to a dirty green.

Many colours may be produced, deſtroyed, and regenerated, upon ſimple mixture. Let dried roſe-

rose-leaves ſtay a while in ſpirits of wine, and and they loſe their colour without tinging the liquor. But add a little oil of vitriol, and it turns red: put in a little urinous ſpirit, and the red changes to green, which by adding a little more oil of vitriol, turns to a red again.

Make a ſlight infuſion of bruiſed galls in water, ſo as not to diſcolour it. Make alſo a weak infuſion of green vitriol in water, which will be ſtill tranſparent. Yet mix them together, and an inky blackneſs will immediately ariſe. But add a little oil of vitriol, the blackneſs will vaniſh, and the liquor be tranſparent again. Yet the blackneſs may be recalled by adding a little ſalt of tartar.

If a little bruiſed camphire which is very white, be put into tranſparent oil of vitriol, the camphire will diſſolve, and tinge the liquor firſt brown, and at length a fine black. But upon the addition of fair water, the blackneſs entirely vaniſhes, and the camphire regains its native whiteneſs.

A tranſparent infuſion of ſugar of lead in water being wrote with, when dried becomes inviſible. But the bare fumes of another tranſparent liquor, namely, infuſion of quick lime and orpiment in water, will quickly make the inviſible writing black and viſible.

And not only ſecondary, but primary colours are producible by ſimple mixture. If the ſun's rays paſs through two pieces of differently coloured glaſs, ſuppoſe a blue and yellow piece laid on each other, and theſe rays are received upon white paper, they produce a beautiful green. A mixture of ſeven, or even five, original colours, will make a pure white. If different coloured flames be brought to mix, the experiment is made to perfection.

Flames from different bodies are of different colours. The flame of camphire is white, of ſulphur blue, of white-wax inclining to yellow. For making experiments, oil may be impregnated with different metals, ſo as to exhibit their particular flames.

4. Air is the ordinary veichle of Sound, which is the fainter, the more remote the ſounding body is. It is alſo leſſened, and ſometimes quite interrupted either by contrary winds or thick vapours floating in the air. It is ſuppoſed, that the ſounding body, excites a kind of undulation or tremulous motion in the air, raiſing as it were waves of air, one of which impells the other till they reach the ear.

Sound moves but little quicker by having the wind with it, as it moves at leaſt thirty three times faſter than the moſt violent wind we know. But it is heard much farther thereby.

That air is the *grand veichle* of Sound, appears from various experiments. A bell in an unexhauſted receiver, may be heard at ſome diſtance: but ſcarce at the ſmalleſt, when it is exhauſted. But it is not the only one. Water too will convey ſound. If you ſtrike a bell under water, the ſound is heard plain, only not ſo loud, and alſo a fourth deeper. And a ſound made in air, is heard under water, with juſt the ſame difference.

Sounds commonly move a mile in about nine ſecond and a quarter. If a gun be diſcharged with its mouth to us or from us, the report comes to us in the very ſame time. It always moves the neareſt way, and equally ſwift from the beginning to the end of its motion.

If

If the unadultating air ſtrikes againſt hard, concave bodies, it rebounds, and occaſions what we call an *echo*. As often as Sound ſtrikes perpendicularly on a wall, behind which is any vault or arch, or even a parallel wall, ſo often it will be reverberated in nearly the ſame line. For a multiplied echo, there muſt be a number of walls and cavities, either behind, or fronting each other.

The echo in Woodſtock-park returns very diſtinctly, in the day ſeventeen, in the night, twenty ſyllables. There is an echo on the bank of the river Naſſa, between Bingen and Collentz in Germany, which repeats what is ſaid ſeventeen times. And what is ſtill more peculiar, the perſon who ſpeaks is ſcarce heard at all, but the repetition clearly, and with ſurprizing variety: the echo ſeeming ſometimes to approach nearer, and ſometimes to be farther off. One perſon hears only one voice, another ſeveral: one hears it on the right, another on the left.

Two miles from Milan there is a ſtill more ſurpriſing echo. It returns the ſound of a piſtol fifty-ſix times. The firſt repetitions follow one another very quick; but they are more diſtinct in proportion as they decay. There are two parallel walls, which beat the ſound back upon each other.

5. The fine *effluvia* from odorous bodies, when they reach our noſtrils, excite the ſenſation of *Smelling*. Some bodies emit theſe moſt when they are moiſt: ſome only when they are warmed or heated. From all ſuch bodies innumerable particles flow, which according to their various ſize, figure, and motion, variouſly affect the olfactory-nerve. But what particular motion, ſize or figure, is required in order to any particular ſmell, who is able to explain?

These effluvia indeed are inconceivably ſmall: ſo that amber and divers other odorous bodies, emit them for many years, without any diſcernable loſs, either as to bulk or weight.

Mr. Boyle ſhews, 1. That the number of particles thus emitted, is exceeding great. 2. That they are of a very penetrating nature. 3. That they move with vaſt ſwiftneſs and in all directions. 4. That there is often a wonderful congruity between the bulk and ſhape of theſe effluvia and the pores of the bodies they penetrate, and laſtly, that they may excite great motions, and thereby make great changes in organized bodies.

That Effluvia are emitted to a very great diſtance we learn from hence, that wines grow turpid in the hogſhead, preciſely at the time that the grapes are ripe in the country whence they were imported. That they are very penetrating, even without loſing their virtue we have a proof from the loadſtone, whoſe Effluvia paſs through the moſt ſolid bodies, without any change of their force. That they occaſion great changes in organized bodies, we have a remarkable proof in a caſe lately publiſhed by Dr. Heiſter, " Making an afternoon's viſit to the Reverend Mr. Sentag, he received me in an apartment where there were three or four flower-pots with white lillies. I aſked him, if he did not find his head affected, when he continued long in the room where they were, and told him, phyſicians thought them dangerous, and I myſelf could not bear them. I therefore begged the window might be opened, that the effiuvia might be diſperſed.

He ordered the window to be opened, and replied, He found no inconvenience from them, being a tall, ſtrong, healthy man. But the Smell being

being ſtill too powerful for me, I was obliged to take my leave of him ſooner than I intended.

The night following he was ſeized with an apoplexy. Dr. Bayer and myſelf were ſent for. We found him with his eyes wide open, but without ſpeech, ſenſe or motion. I told Dr. Bayer what had paſſed the day before. We ordered bleeding, bliſters, and ſtrong friction of the ſoles of the feet, head, and hands, with the other remedies uſual in thoſe caſes: but without ſucceſs; for the next morning he began to rattle in the throat, and ſoon after died."

This may admoniſh thoſe to whom theſe odours are not ſenſibly prejudicial, not to ſtay long within the ſphere of their activity.

In ſome places Effluvia from the earth produce many effects on the ſurface of it. The bubbling and boiling fountains in England and other countries are chiefly occaſioned by the burſting up of their Effluvia. Our burning well in Lancaſhire has no peculiar property in its water: but an inflammable vapour riſing through it, makes it boil and bubble on the ſurface. And this vapour, as ſoon as ſet at liberty from the water will take flame at a lighted candle.

The famous boiling ſpring near Montpelier, is likewiſe no other than common water, through which a vapour of the ſame kind makes its way. Indeed all the ſprings thereabouts, bubble more or leſs; the vapour making its way through the whole ſurface of the earth. Water taken out of that ſpring has no ſuch property, nor any peculiar taſte or virtue. What is a farther proof is, the cracks of the earth thereabouts, all perſpire ſtrongly a vapour of this kind: ſo that if ſtraws be laid on the ſurface, they will be blown up, and if an hole be any where dug in the ground, and water poured into it, it will boil up in the ſame manner as the ſpring.

The like ſort of ſprings are common in Switzerland, and ſome other places. Theſe are known to be owing to Effluvia from beneath by the water of them being cold. But there are others which actually boil, and are hot enough to boil an egg. Such are the famous boiling fountains, of Solfatara, near Naples.

From theſe various ſprings we find that there is much variety of this kind of exhalations: ſome being cold and dry: ſome of a bituminous nature, and not actually cold, as ours in Lancaſhire: ſome hot as thoſe in the ſweating vaults and caverns, and in the mountains of Italy. Others are of a poiſonous nature, containing particles of arſenic, or other poiſonous minerals.

6. Many bodies are taſteleſs. But ſome even of theſe may contract a very ſtrong *taſte* (as do ſeveral metals) when they are reſolved into a fine powder. Some bodies by ſeveral other changes, acquire Taſtes which they had not before, or variouſly increaſe, leſſen or alter their Taſte. Hence it has been ſuppoſed, that all Taſtes proceed from ſalts, which are often ſo inveloped, that they cannot exert their power. But if the containing bodies are diſſolved by fire or liquors, then they variouſly affect the nerves in the tongue and palate. And hence ariſe all the various ſenſations of Taſte. But what particular ſize, ſhape or motion of the particles, is required to produce any particular Taſte, all our ſkill cannot determine.

7. Of the properties which we perceive by *Feeling*, the chief are *Moiſtneſs*, *Dryneſs*, *Heat* and *Cold*. There is no Heat without fire, or at leaſt

leaſt ſome diſpoſition of the heated body to take fire. If the particles of it, rapidly agitated, ſtrike againſt another body, they tear and diſſolve it: if againſt the body of a man, the ſenſation of Heat ariſes in the mind. Some ſuppoſe, *Cold* conſiſts in the reſt of thoſe particles which were ſo agitated before. Others think this would not ſuffice to produce that acute pain which we ſometimes feel from Cold: and therefore ſuppoſe there are poſitive frigorific particles, which move on in ſtrait lines, and ſo not only deſtroy the circular motion which is required for Heat, but likewiſe penetrate the body, and ſharply affect the extremities of the nerves.

8. *Gravity* and *Levity* have likewiſe been reckoned among ſenſible qualities. But properly, there is no ſuch a thing as Levity, for all bodies tend to the center of the earth, though ſome are *light* in compariſon of others. The laws of Gravity are, 1. All bodies on the earth, tend to a point which is (nearly at leaſt) the center of the globe. 2. In all places equidiſtant from the center, the force of Gravity is nearly equal. 3. Gravity equally affects all bodies, without regard either to their bulk or figure. So that were it not for the reſiſtance of the medium, the greateſt and ſmalleſt bodies, the moſt denſe, and the moſt rare, would deſcend equal ſpaces in equal times. Thus gold and feathers deſcend alike in an exhauſted receiver. 4. This power increaſes as we deſcend to the center, and decreaſes as we aſcend from it: and that as the ſquares of the diſtances. Thus at a double diſtance, Things have but a quarter of the force. 5. Thoſe things ſwim in fluids, which are ſpecifically (that is, bulk for bulk) lighter than thoſe fluids.

This gravitating power seems to be congenial to matter. It penetrates even to the center of the sun and other heavenly bodies, without any diminution of its virtue. And it acts not according to the surfaces of bodies, as mechanical causes do, but according to the quantity of matter they contain. That it is an original law of nature, immediately impressed by the Creator, without dependance on any second cause at all, may appear from the following considerations, 1. Gravity does not require the presence of the gravitating or attracting body. 2. The distance being the same, the velocity wherewith gravitating bodies move, depends on the quantities of matter in the attracting body. And the velocity is not changed, let the mass of the gravitating body be what it will. 3. If Gravity depend on any known law of motion, it must be some impulse from an extraneous body: whence, as Gravity is continual, a continual stroke must also be required. Now if there be any such matter continually striking on bodies, it must be subtle enough to penetrate all bodies. But how should matter subtle enough to penetrate the hardest bodies, and so rare as not sensibly to hinder the motion of any, be able to impel such vast bodies toward each other with such force? How does this force encrease, according as the mass of that body, toward which any body moves increases? Whence is it, that all bodies at the same distance from the body gravitated to, move with the same velocity? And how can matter, which only acts on the surface of the bodies themselves, or of their internal particles, communicate such motion as in all bodies shall exactly follow the proportion of the quantity of matter in them?

But

But after all comes Mr. Hutchinſon, calls Sir Iſaac and all his followers ſenſeleſs, unphiloſophical blockheads, and to ſolve all the difficulty in a moment, ſuppoſes the ſun to be the center of the whole univerſe, and to project Light every way, through every point of ſpace, to the utmoſt circumference of it. When this Light arrives at the circumference, it is condenſed into larger maſſes, and returns in the form of Spirit or Air, through every point of ſpace to the ſun. There it is again comminuted into light by the immenſe Fire, and ſo iſſues out again to the circumference. And this double impulſe of Light moving outward, and Spirit moving inward, cauſes the motion of all the heavenly bodies, both round their own axies and round the ſun. But to wave that groſs abſurdity, of ſuppoſing every point of ſpace to be continually filled with light, and every point of it to be filled with ſpirit at one and the ſame time, (which is flatly impoſſible, ſince both are material, and two particles of matter cannot co-exiſt in the ſame ſpace:) how does this remove the difficulty at all? How does it help us forward an hair's breadth? For what impels light outward, or ſpirit inward? It can be no mechanical power. It muſt then be the finger of God. And if ſo, what have we gained? May we not as well ſay at once, (as go thus round about) " Gravitation can be no otherwiſe accounted for, than by allowing the direct, immediate power of God, operating through the whole univerſe?"

But beſide the Attraction of Gravity, there is another ſpecies of Attraction, between the minute particles whereof bodies are compoſed. Theſe attract each other at or near the point of contact, with

with a force much ſuperior to that of Gravity. It is by this Attraction of Coheſion, that the atoms or inſenſible particles of bodies are united into ſenſible maſſes. Hereby numberleſs phænomena may be accounted for, which are otherwiſe inexplicable: ſuch as coagulation, chryſtallization, and the aſcent of fluids in capillary tubes. Such likewiſe are fermentation, animal ſecretion, and many others. Thus nature will be found very ſimple and conformable to herſelf, performing all the great motions of the heavenly bodies, by the Attraction of Gravity between thoſe bodies, and almoſt all the motions of their ſeveral parts, by this Attraction diffuſed through every particle. Sir Iſaac thinks, that without theſe two principles there would be no motion in the world. And without the continual operation of them, it could not long continue, conſidering the vaſt and conſtant diminution of motion by various other cauſes.

Mr. Hervey's obſervations on this head, are ſtrong and beautiful.

" The fundamental laws of our modern aſtronomy are *projection* and *attraction:* one the all-combining cement, the other the ever-operative ſpring of the mighty frame. In the beginning God impreſſed a proper degree of motion on each of the whirling orbs. This, if not controlled, would have carried them on in ſtrait lines, till they were loſt in the abyſs of ſpace. But the principle of *gravitation* being added thereto, determined their courſe to a circular form. And how neceſſary for the conſervation of the univerſe, is both the one and the other? Were the projectile

projectile power to ceafe, all the harmonioufly-moving fpheres would fall into the central fire. Were they gravitating, they would exorbitate into wild confufion, or by their rapid whirl be diffipated into atoms. But the impulfive and attractive energy, being nicely attempered to each other, the various globes perfevere in their radiant courfe, without any interruption or diminution. †

" How extenfive, and how diverfified is the force of this fingle principle of *attraction?* (Underftanding by the word, that of cohefion, as well as of gravitation!) It penetrates the very effence of all bodies, and diffufes itfelf to the utmoft limits of the mundane fyftem. By this all thofe vaft worlds of matter hang felf-balanced on their centers. And to this is owing an effect of a very different nature, the *preffure* of the atmofphere, which though a yielding and expanfive fluid, yet by virtue of an attracting energy furrounds the whole globe of earth, and inclofes every creature thereon, as it were with a tight bandage: an expedient abfolutely neceffary to preferve the texture of our bodies, and indeed of every animal. Urged by this, the *rivers* circulate with a never-failing current, along the veins of the earth. Impelled by the fame myfterious force, the *nutritious juices* are detached from the foil, and afcending the trunks of trees, find their way through millions of the fineft meanders, in order to convey vegetative life into the fmalleft branches. This confines the *ocean* within its bounds. Though the waves thereof roar and fwell, yet checked by this

† All this is fpoken on the Newtonian Hypothefis.

this curb, they are unable to pafs, even the flighteft barrier of fand. To this the *mountains* owe that unfhaken firmnefs, which laughs at the fhock of careering winds. By virtue of this invifible mechanifm, without any inftrument of human device, thoufands of tons of *water* are raifed every moment into the regions of the firmament. By this they continue fufpended in the air, without any ciftern to contain them. By the fame varioufly-acting power, they in due time drop down again in gentle falls of *dew*, or are precipitated in copious fhowers of *rain*. They flide down in fleecy flights of *fnow*, or dart in clattering fhowers of *hail*. This occafions the ftrong *cohefion* of *folid bodies*, without which our large machines would be utterly ufelefs, and the nicer utenfils of life elude our expectations of fervice. In fhort, this is the *ballaft* which compofes the equilibrium, and conftitutes the ftability of things: this the great *chain*, which forms the connexion of univerfal nature, and the mighty *engine*, which in good meafure accomplifhes almoft all her operations. What complicated effects from a fingle caufe! What profufion amidft frugality!"

How extremely plaufible is all this! And what pity, that it is only *plaufible!* But it is really no more: it is not capable of any fubftantial proof; I mean, with regard to the motion of the heavenly bodies, and the caufes of that motion.

I do not know that any one has yet given a rational anfwer to Dr. Rogers' obfervations on that head. " The action of thefe two powers (*gravitation* and *projection*) is inadequate to fuch a motion:

motion: becauſe in order to produce it, the gravitating force muſt exactly balance the projectile. But were this done, one would deſtroy the other. This will appear plain, if we conſider the nature of theſe two forces. Gravitation, by which the earth attracts all bodies, is at all times uniformly exerted in right lines, from the earth to the body attracted, and acts equally on all bodies according to their denſities. It is perpetual, ſubject to no decay, needing no reparation. But Projection is a motion given to a body, contrary to its nature. When given, it would always continue in a ſtrait line, if nothing hindered it; but cannot remove any obſtruction, without loſing part of its own force. Now the obſtruction given by attraction, muſt have the ſame effect as obſtruction given by air or ether: it muſt continually leſſen any projectile force, till that force is totally deſtroyed.

A mortar elevated forty-five degrees, ejects a bomb at firſt in or near a right line, while the projectile force is vaſtly ſuperior to the attractive; afterwards in a curve: for the moment the two forces are in equilibrio, in a ſegment of a circle; then in a curve leſs and leſs bent, till it falls in a right line to the center of gravitation.

This is the nature of all Projectiles: nor can any Projectile, thrown in any direction, by any force of Attraction, produce a circular motion; much leſs an elliptical one, ſuch as that of the earth. Beſides, what phyſical reaſon can be aſſigned, why the earth, being nearer the ſun in winter, the gravitating force does not increaſe; and why the projectile does not increaſe in ſummer,

mer, when it is farther from the ſun, to the entire deſtruction of one or the other?

A third motion alſo is ſuppoſed to be primarily impinged on the earth, namely, round its own axis. But nothing can be more plain, than that a body ſo ſtrongly attracted by the ſun, as to keep it from flying off in a tangent, muſt have its circular motion preſently ſtopt: as the ſide next the ſun muſt be attracted moſt, the attraction of all the planets co-operating thereto.

To make this plain, I hung a loadſtone to a ſmall ſtring, and gave it as many turns as would continue its revolving motion ten minutes and an half, when no iron was near. But on bringing a piece of iron near, it ſtopped. The iron being removed, it recommenced its circular motion, which laſted for a minute more. Hence it is evident, that did not ſome force continually act upon the earth, to keep up its motions, the attractive power of the ſun would ſoon ſtop, at leaſt the diurnal one.

The Friction likewiſe of the ether muſt be conſiderable. Elſe why might not the earth revolve in twenty-four minutes as well as twenty-four hours? Indeed this ſeems to be one great uſe of the ether, to prevent the too rapid motions of the planets. And as the earth floats in the air, ſo does the ſun in the ether, his proper atmoſphere, which extends to the utmoſt limits of his ſyſtem, and is the medium, Funiculi or Hami, by which he attracts all the planets and comets, and prevents their flying out of the ſyſtem.

Neither

Neither will Gravitation at all account for the Motion of Comets. That in 1680 defcending from an immenfe height perpendicularly toward the fun, rofe from him again with equal velocity. Now as its accefs to, and recefs from the fun, were made in ftrait lines, while they were making, the projectile force muft ceafe. But to ftop any projectile, is to deftroy its motion. How came it then to be fo ftrongly exerted in the Perihelion? Was there a continued miracle, a frefh projection given? Or did it rebound? What, from the yielding ether!

Again. This Comet, during half its circuit round the fun, was diftant from it but one third of the moon's diftance from the earth. The attractive force therefore was then vaftly increafed; and the projectile being deftroyed, it muft have impigned on the fun long ago, had there been no other force to prevent it. It is clear then upon the whole, that the motions of the heavenly bodies, cannot be accounted for, by attraction and projection.

How then can they be accounted for? Poffibly thus. The earth being an oblate Spheroid, objected to the fun in an obliquity of 66 degrees 30 minutes, (the fame which given to the fails of a windmill, occafions its moft forcible converfion) the fun's rays ftriking againft the oblique hemifphere, as the wind againft the fails of a windmill, keep it off, and at the fame time make it turn on its own axis. The ether being a refifting medium, and the atmofphere (like the oars of a boat) ftriking therein, urges it into a progreffive motion. Meantime its own gravity inclines it to the fun's center,

center, and of courſe keeps it in equilibrio, with the repelling rays.

It is ſuppoſed likewiſe, that the plane of the earth's orbit, is in winter in or near the ſun's axis, whence the rays are not ſo forcibly emitted; for which cauſe the earth muſt then come nearer, the repelling force being weaker. But in ſummer, being objected to the more forcibly repelling rays, it muſt be driven to a farther diſtance; whence its annual orbit muſt become elliptical.

The earth's diameter being known, determines its diſtance from the ſun. For as the diameter is 7967, the periphery 25031, which multiplied by the number of its revolutions 36,525, gives for its orbit 9,142,572: and as it moves through this orbit merely by the impulſe of the ſolar rays, and as the gravitating force muſt neceſſarily be equal to that impelling force; ſo while it rolls onward one mile, it is attracted another. Conſequently the preceding orbit being doubled, by the gravitating force, makes in all 18,285,144. The ſemidiameter of this is the diſtance of the earth from the ſun: which therefore is neither more nor leſs than 2,910,364 miles.

In the ſame manner we find the diſtance of Venus from the ſun, to be 1,790,684 miles: that of Mars, 5,473,690: that of Jupiter, 34,520,432: that of Saturn, 85,727,320: and that of Mercury, 700,758.

And as theſe diſtances are far leſs than thoſe aſſigned by the modern aſtronomers; ſo is the magnitude of the heavenly bodies proportionably leſs

leſs than they ſuppoſe. For inſtance: the diameter of the ſun, commonly ſuppoſed to be 822,148 miles, is according to this manner of calculating, 23,373 and no more. And that this is nearly the true diameter, and theſe the true diſtances, appears from experiments on the tranſits of the planets over the ſun."

The Comets, Dr. Rogers thinks, are chiefly deſigned to repair the quantities of light continually emitted by the ſun, and which are ſcattered and diſperſed over the whole ſyſtem. Their ſweeping tails, which extend ſo many thouſand miles, ſeem adapted to ſuch a purpoſe. And as many of thoſe particles of light, are driven to a vaſt diſtance, it is neceſſary they ſhould go to the utmoſt limits of the ſyſtem, to make ſuch a collection.

Suppoſe a body fit for this, detached from the neighbourhood of the ſun, it ſhould be light, porous and ſpongy. And ſuch a body would be propelled by the violence of the rays, with great velocity to a great diſtance. The farther it goes, the fewer rays ſtrike upon it, and their force likewiſe is diminiſhed. The Comet then ſlowly ſweeps his tail over the wide expanſe, beyond the orbit of Saturn. There its cells are filled with the matter it was ſent to collect; but becoming heavier, the other ſcale begins to preponderate, and he ſlowly returns toward his center. His collection increaſes as he deſcends, which adds to his weight and ſwiftneſs, and he comes down, if very heavy, almoſt in a ſtrait line; if leſs ſo, in a larger curve, till he is near the ſun, where having emptied himſelf, and being evenly balanced with the repelling

repelling rays. he moves round in the ſegment of a circle, till being continually lighter, he is no longer a balance for the repelling rays, and ſo is driven forward thereby, and runs the ſame circle as before.

What a violent blow is here given to the whole ſabric of modern aſtronomy! And how can any reaſonable man ſubſcribe thereto, till this difficulty is removed?

9. There is no need to ſpeak particularly of thoſe other qualities, *hardneſs*, *ſoftneſs*; *firmneſs*, *fluidity*; *brittleneſs*, *toughneſs*; *roughneſs*, *ſmoothneſs*, *denſity*, *rarity*; *regidity*, *flexibility*, *compreſſibility*, *elaſticity*. What each of theſe is, we know well, without any elaborate definition. And in general we know, that they all ariſe from the various figure, ſituation and texture of the particles whereof bodies conſiſt. But farther than this we know not. What particular ſhape, texture, or ſituation, is requiſite in each caſe, is a matter of mere conjecture.

10. Thoſe of which we are not able to give any rational account, have often been termed *Occult Qualities*. Among theſe is uſually ranked that *ſympathy*, which is obſerved in things diſtant from each other. So onions in the granary ſprout, while others ſprout in the garden. So nothing is more common, than that if you throw a mulbery or ſtrawbery at a woman with child, the child has the mark of one or the other, on the ſame part which was ſtruck with it. And theſe marks grow green, yellow and red every year, juſt as thoſe fruits do in the garden. And when the
ſeaſon

ſeaſon of them is paſt, theſe ſubſide, and vaniſh away. So women ſtartled by a ſudden ſight of the moon, have ſtamped the figure of the moon on their children. And this figure increaſed or decreaſed juſt as the moon did. Oppoſite to this, is that amazing *antipathy*, which ſome things appear to have naturally for each other. Inſtances of which are found, not only in men, but in animals, if not in plants alſo.

Before we attempt to account for any of theſe things, we ſhould take care to be well aſſured of the fact. For many of them are generally believed and vehemently aſſerted, which yet never had any being. Hence others run into the oppoſite extreme, roundly denying whatever they cannot account for. The middle way is beſt. Firſt, be ſure of the fact. Then, try if it can be accounted for on allowed principles. And if it can, the qualities in queſtion, are to be termed *Occult* no longer. But there will ſtill remain many ſecrets in nature, which we are in no wiſe able to account for. Indeed to penetrate the inmoſt receſſes of nature, is above the condition of humanity. We muſt therefore neceſſarily allow, that there are in this ſenſe many Occult Qualities: nay, we are ſurrounded with them on every ſide: inſomuch that there is ſcarce any thing in the univerſe, that has not ſome qualities, which the wiſeſt man on earth is not able to account for.

11. I have now finiſhed what I propoſed. I have given as ſhort and plain an account as I could, of all that is certain in Natural Philoſophy: In order to direct the whole to its proper end, I have now only to add a few Reflections.

If

If we cast our eyes up to the firmament, let us seriously ask ourselves, What power built over our heads that vast and magnificent arch, and *spread out the heavens like a curtain?* Who garnished these heavens with such a variety of resplendant objects, all floating in the liquid ether, all regular in their motions? Who painted the clouds with such variety of colours, and in such diversity of shades and figures, as it is not in the power of the finest pencil on earth to emulate? Who formed the sun of such a determinate size, and placed it at such a convenient distance, as not to scorch or annoy, but to cherish all things with his genial heat? For a succession of ages he never failed to rise at his appointed time, or to send out the dawn as his forerunner, to proclaim his approach. By whose skilful hand is it directed, in its diurnal and annual course, to give us the grateful vicissitude of night and day, and the regular succession of the seasons? That it should always proceed in the same path, and never once step aside: that it should go on, in a space where there is nothing to obstruct, but turn at a determinate point: that the moon should supply the absence of the sun, and remove the horror of the night; that it should regulate the flux and reflux of the sea, thereby preserving the waters from putrefaction, and at the same time accomodating mankind with so manifold conveniences: that all the innumerable hosts of heaven, should perform their revolutions with such exactness, as never once to fail, in a course of six thousand years, but constantly to come about in the same round to the hundredth part of a minute: this is such an incontestable proof of a Divine Architect, and of the care and wisdom wherewith he governs the verse, as made the Roman Philosopher conclude, "Whoever imagines, that the wonderful order and incredible constancy of the heavenly bodies and their motions, whereon the welfare and preservation of things depend, are not governed by an intelligent Being, is himself destitute of understanding. For shall we, when we see an artfully contrived engine, suppose a dial or sphere, immediately acknowledge that it is the result of reason and understanding: and yet, when we behold the heavens, so admirably contrived, moved with such incredible velocity, and finishing their anniversary revolutions, with such unerring constancy, make any doubt of their being the work not only of reason, but of an excellent, a Divine reason?"

But if from that very imperfect knowledge of astronomy which his time afforded, even the heathen could be so confident, that the heavenly bodies were framed and moved by a wise and understanding mind: what would he have said, had he been acquainted with our modern discoveries? Had he known the immense greatness of that part of the world, which falls under our observation? The exquisite regulation of the motions of the planets, without any deviation or confusion: the inexpressible nicety of adjustment, in the velocity of the earth's annual motion; the wonderful proportion of its diurnal motion about its own axis; the densities of the planets, exactly proportioned to their distances from the sun: the admirable order of the several satellites, which move round their respective planets; the motion of the Comets equally regular and periodical, with that of the other planetary bodies; and lastly, the preservation of the several planets and Comets, from falling upon, or interfering with each other? Certainly could argument avail, Atheifm would now be utterly afhamed to fhew its head, and forced to acknowledge, That it was an Eternal and Almighty Being, it was God alone, who gave to each of the celeftial bodies, its proper magnitude and meafure of heat, its duenefs of diftance, and regularity of motion: or in the language of the prophet, who *eftablifhed the world by his wifdom, and ftretched out the heavens by his underftanding,*

If from the firmament we defcend to the orb on which we dwell, what a glorious proof have we of the Divine Wifdom, in this intermediate expanfion of the air, which is fo wonderfully contrived, to anfwer fo many important ends at once? It receives and fupports clouds, to water the earth. It affords us winds, for health, for pleafure, for a thoufand conveniences: by its fpring, it minifters to the refpiration of animals, by its motion, to the conveyance of founds, and by its tranfparency, to the tranfmiffion of light, from one end of heaven to the other. Whofe power made fo thin and fluid an element, a fafe repofitory for thunder and lightning? By whofe command and out of whofe treafuries, are thefe dreadful, yet ufeful meteors fent forth, to purify the air, which would otherwife ftagnate, and confume the vapours that would otherwife breed various difeafes? By what fkilful hand are thofe immenfe quantities of water, which are continually drawn from the fea, by a natural diftillation made frefh, fent forth upon the wings of the wind, into the moft diftant countries, and diftributed in fhowers over the face of the earth?

Whofe

Whose power and wisdom was it that hanged the earth upon nothing, and gave it a spherical figure, the most commodious which could be devised, both for the consistency of its parts, and the velocity of its motion? Who was it that *weighed the mountains in scales, and the hills in a balance*, and disposed them in their most proper places, both for fruitfulness and health? Who diversified the climates of the earth, into such an agreeable variety, that, remote as they are from each other, each has its proper seasons, day and night, winter and summer? Who was it that cloathed the face of it with plants and flowers, so exquisitely adorned with various and inimitable beauties? That placed the plant in the seed, in such elegant complications, as afford at once both a pleasing and an astonishing spectacle? That painted and perfumed the flowers, that gave them the sweet odours which they diffuse through the air for our delight, and with one and the same water dyed them into different colours, surpassing the imitation, nay, and the comprehension of mankind? For can the wisest of men tell,

"Why does one climate and one soil endue
The blushing poppy with a crimson hue,
Yet leave the lilly pale, and tinge the violet blue."

Who replenished the earth, the water, the air with such an infinite variety of living creatures, and so formed, that of the innumerable particulars wherein each creature differs from all others, every one is found upon examination, to have its singular beauty and peculiar use. Some walk, some creep, some fly, some swim. But every one has all its members and its various organs accurately fitted for its peculiar motions. In ſhort, the ſtatelineſs of the horſe, and the feathers of the ſwan, the largeneſs of the elephant, and the ſmallneſs of the mite, are to a conſiderate mind equal demonſtration of an infinite wiſdom and power. Nay, rather the ſmaller the creature is, the more amazing is the workmanſhip. When in the mite, for inſtance, we ſee an head, a body, legs and feet, all as well proportioned as thoſe of an elephant, and conſider withal that in every part of this living atom, there are muſcles, nerves, veins, arteries, and blood, every particle of which blood is compoſed of various other particles: when we conſider all this, can we help being loſt in wonder and aſtoniſhment? Can we refrain from crying out, on this account alſo, *O the depth of the riches both of the wiſdom, and knowledge of God! How unſearchable are his works, and his ways* of creation and providence *paſt finding out!*

Natural inſtinct is another thing in animals, no leſs wonderful than their frame: and is indeed nothing elſe than the direction of an all-wiſe and all-powerful mind. What elſe teaches birds to build their neſts, hard or ſoft, according to the conſtitution of their young? What elſe makes them keep ſo conſtantly in their neſt, during the time of incubation, as if they knew the efficacy of their own warmth, and its aptneſs for animation? What elſe cauſes the ſalmon every year to come up a river, perhaps hundreds of miles, to caſt its ſpawn, and ſecure it in banks of ſand, till the young ones are excluded? To go no farther, can we behold the ſpiders net, the ſilk worms web, the bees cells, or the ants granaries, without being

being forced to acknowledge the Infinite Wiſdom, which directs their unerring ſteps, and has made them fit to be an emblem of art, induſtry and frugality to mankind?

If from the earth and the creatures that live upon it, we caſt our eyes upon the water, we ſoon perceive that had it been more or leſs rarefied, it had not been ſo proper for the uſe of man. And who gave it that juſt configuration of parts and exact degree of motion, which makes it ſo fluent, and yet ſo ſtrong as to carry, and waft away the moſt enormous burdens? Who has inſtructed the rivers to run in ſo many winding ſtreams, through vaſt tracts of land, in order to water them the more plentifully? Then to diſembogue themſelves into the ocean, ſo making it the common center of commerce: and thence to return through the earth, as air to their fountain heads, in one perpetual circulation? Who repleniſhed theſe rivers with fiſh of all kinds, which glide through the limpid ſtreams, and run heedleſsly into the fiſhers net, for the entertainment of men? The great and wide ſea is a very awful and ſtupendous work of God. Whoſe hand makes it ebb and flow with ſuch exactneſs? A little more or leſs motion in the fluid maſs, would diſorder all nature, and a ſmall increaſe of a tide, might ruin whole kingdoms. Who then was ſo wiſe as to take exact meaſures of thoſe immenſe bodies, and who ſo ſtrong as to rule at pleaſure the rage of that furious element? He *who hath placed the ſand for the bound of theſe, by a perpetual decree that it cannot paſs.* So that *though the waves thereof toſs themſelves, they cannot prevail, though they roar, they cannot paſs over it.*

If from the world itſelf we turn our eyes more particularly on man, whom it hath pleaſed the Lord of all to appoint for its principal inhabitant, no underſtanding ſurely can be ſo low, no heart ſo ſtupid and inſenſible, as not plainly to ſee, that nothing but infinite wiſdom, could in ſo wonderful a manner have faſhioned his body, and breathed into it a reaſonable ſoul, whereby he *teacheth us more than the beaſts of the field, and maketh us wiſer than the fowls of heaven.*

Should any of us ſee a lump of clay riſe immediately from the ground, into the compleat figure of a man, full of beauty and ſymmetry, and endowed with all the powers and faculties, which we perceive in ourſelves, yea, and that in a more eminent degree of perfection, than any of the preſent children of men: ſhould we preſently after obſerve him perform all the offices of life, ſenſe and reaſon; move as gracefully, talk as eloquently, reaſon as juſtly, and diſcharge every branch of duty, with as much accuracy as the moſt accompliſhed man breathing, how great muſt be our aſtoniſhment! Now this was the very caſe in that moment when God created man upon the earth.

But to impreſs this in a more lively manner upon the mind, let us ſuppoſe the figure above mentioned, riſes by degrees, and is finiſhed part by part in ſome ſucceſſion of time. When the whole is completed, the veins and arteries bored, the ſinews and tendons laid, the joints fitted, the blood and juices lodged in the veſſels prepared for them, God infuſes into it a vital principle. The image moves, it walks, it ſpeaks. Were we

to

to ſee all this tranſacted before our eyes, we could not but be aſtoniſhed! A conſideration of this made David break out into that rapturous acknowledgment, *I will give thee thanks, for I am fearfully and wonderfully made! Marvellous are thy works, and that my ſoul knoweth right well. Thine eyes did ſee my ſubſtance yet being imperfect, and in thy book were all my members written.*

Thus which way ſoever we turn our eyes, whether we look upward or downward, without us, or within us, upon the animate or inanimate parts of the creation, we find abundant reaſon to ſay, *O Lord, how manifold are thy works! In wiſdom haſt thou made them all.*

Let us obſerve a little farther the terraqueous globe. How admirably are all things thereon chained together, that they all aim at the ultimate end, which God propoſed in all his works! And how vaſt a number of intermediate ends are ſubſervient to this! To perpetuate the eſtabliſhed courſe of nature, in a continued ſeries, the Divine Wiſdom has thought fit, that all living creatures ſhould conſtantly be employed in producing individuals; that all natural things ſhould lend an helping hand, toward preſerving every ſpecies, and laſtly, that the deſtruction of one thing ſhould always conduce to the production of another.

This globe contains what are called the three kingdoms of nature, the *foſſile*, *vegetable*, and *animal*. The foſſile conſtitutes the cruſt of the earth, lying beneath the viſible ſurface. The vegetable adorns the face of the globe, and draws much of its nourishment from the fossile kingdom. The animal is almost wholly sustained by the vegetable kingdom. If we go deeper into the earth, the rule which generally obtains with regard to the strata thereof is this. The upper parts consist of rag-stone, the next of slate, the third of marble filled with petrefactions, the fourth of slate again, and lastly, the lowest which we are able to discover, of free stone.

That the sea once overspread a far greater part of the earth, than it does at present, we learn not only from geographers, but from its yearly decrease, observable in many places: partly occasioned by the vast quantities of shells and all kinds of rubbish, which the tides continually leave on the shores. Hence most shores are usually full of wreck, of dead, testaceous animals, of stones, dirt or sand of various kinds, and heaps of other things. Rivers likewise, especially those which have a rapid stream, wear away whatever they touch, particularly soft and friable earth, which they carry and deposit on distant, winding shores: whence it is certain the sea continually subsides, and the land gains no small increase.

Water retained in low grounds occasions marshes. But what a wonderful provision has nature made, that many of these even without the help of man, shall again become firm ground? More and more mossy tumps are seen therein. Some of these are brought down by the water, from the higher grounds adjoining, and others are produced by putrifying plants. Thus the marsh is dried up, and new meadows arise. And this is done in a shorter time, whenever the *sphaguum*, a kind a kind of moſs, has laid the foundation. For this in proceſs of time, changes into a porous kind of mold, till almoſt all the marſh is filled with it. After this the ruſh begins to ſtrike root, and together with the cotton-graſſes, conſtitutes a turf, wherein the roots get continually higher, and thus lay a firm foundation for other plants, till the whole marſh is covered with herbs and graſs, and becomes a pleaſant and fruitful meadow.

I ſhall add only one reflection more, with regard to the *Scale of beings*. As the microſcope diſcovers almoſt every drop of water, every blade of graſs, every leaf, flower, and grain of earth, to be ſwarming with inhabitants: a thinking mind is naturally led to conſider that part of the ſcale of beings, which deſcends lower and lower, from himſelf, to the loweſt of all ſenſitive creatures. Among theſe ſome are ſo little above dead matter, that it is hard to determine whether they live or no. Others that are lifted one ſtep higher, have no ſenſe beſide feeling and taſte. Some again have the additional one of hearing: others of ſmell, and others of ſight.

It is wonderful to obſerve, by what a gradual progreſſion the world of life advances, through an immenſe variety of ſpecies, before a creature is found, that is complete in all its ſenſes. And among theſe there are ſo many different degrees of perfection in the ſenſes which one animal enjoys above another, that though each ſenſe in different animals, comes under the ſame common denomination, yet it ſeems almoſt of a different nature. If after this, we attentively conſider, the inward endowments of animals, their cunning

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and ſagacity, and what we uſually comprehend under the general name of *inſtinct*, we find them riſing one above another, in the ſame imperceptible manner, and receiving higher and higher improvements, according to the ſpecies in which they are implanted.

The whole progreſs of nature is ſo gradual, that the entire chaſm from a plant to man, is filled up with divers kinds of creatures, riſing one above another, by ſo gentle an aſcent, that the tranſitions from one ſpecies to another, are almoſt inſenſible. And the intermediate ſpace is ſo well huſbanded, that there is ſcarce a degree of perfection which does not appear in ſome. Now ſince the ſcale of being advances by ſuch regular ſteps as high as man, is it not probable, that it ſtill proceeds gradually upwards, through beings of a ſuperior nature? As there is an infinitely greater ſpace between the Supreme Being and man, than between man and the loweſt inſect.

This thought is thus enlarged upon by Mr. Lock. " That there ſhould be more ſpecies of intelligent creatures above us, than there are of ſenſible and material below us, is probable from hence, that in all the viſible and corporeal world, we ſee no chaſm, no gaps. All quite down from man, the deſcent is by eaſy ſteps: there is a continued ſeries of things that in each remove differ the leaſt that can be conceived from each other. There are fiſhes that have wings, and are not ſtrangers to the airy regions. And there are birds which are inhabitants of the waters, whoſe blood is as cold as that of fiſhes. There are animals ſo near a-kin both to birds and beaſts, that they are

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in the middle between both. Amphibious animals link the terreſtrial and aquatic together. Seals live either on land or in the ſea. Porpuſſes have the warm blood and entrails of an hog. There are brutes that ſeem to have as much knowledge and reaſon, as ſome that are called men. Again: the animal and vegetable kingdoms are ſo cloſely joined, that between the loweſt of the one, and the higheſt of the other, there is ſcarce any perceptible difference. And if we go on, till we come to the loweſt and moſt inorganical parts of matter, we ſhall find every where, that the ſeveral ſpecies are linked together, and differ in almoſt inſenſible degrees.

Now when we conſider on the other hand, the infinite power and wiſdom of the Creator, does it not appear highly ſuitable, to the magnificent harmony of the univerſe, and the infinite goodneſs of the architect, that the ſpecies of creatures ſhould alſo by gentle degrees aſcend upwards from us, (as they gradually deſcend from us downwards) toward his infinite perfection? And if ſo, is it not probable, there are far more ſpecies of creatures above then beneath us? Since we are infinitely more remote from the all-perfect Creator, than from the loweſt of all the works of his hands?

But here our thoughts are loſt. We may conjecture a little; but we *know* nothing. However, it is enough, that we *know the only true God, and Jeſus Chriſt whom he hath ſent.*"

This reflection upon *the scale of beings*, is pursued at large, by one of the finest writers of the age, Mr. Bonnét of Geneva, in that beautiful work, "The Contemplation of Nature." When I first read this, I designed to make only some extracts from it, to be inserted under their proper heads. But upon farther consideration, I judged it would be more agreeable, as well as profitable to the reader, to give an abridgement of the whole, that the admirable chain of reasoning may be preserved, and the adorable Wisdom and Goodness of the great Author of nature, placed in the strongest light.

INTRODUCTION.

I Raise myself up to the ETERNAL REASON; I study his laws, and I adore him. I contemplate the universe with a philosophic eye. I search into the relations which by this immense chain constitute one whole. I stop a while to examine some links of it, and, struck with those marks of power, wisdom, and goodness which I discover therein, I faintly attempt their description.

CHAP.

CHAP. I.

Of the FIRST CAUSE.

1. TO be ſelf-exiſtent, endued with Almighty Power, and to will with Infinite Wiſdom, are the adorable Perfections of the Firſt Cauſe.

The univerſe is eſſentially derived from this Cauſe. In vain do we endeavour by other means to account for it. We may every where obſerve order and ends; the effects of an ETERNAL, SELF-EXISTENT REASON.

2. What mind can fathom the depths of this abyſs? What thought can comprehend that Power which calls things that are not as though they were? God commands the univerſe to be: the univerſe is inſtantly produced.

A ſingle act of his will produced the univerſe; the ſame act preſerves it.

But you aſk, Why is not man as perfect as an angel? You mean to ſay, no doubt, Why is not man an angel? You may as well enquire, Why a ſtag is not a man? But the exiſtence of a ſtag ſuppoſes that of herbs to nouriſh him. Would you ſtill further have had theſe herbs to have been ſo many men? Their preſervation and increaſe would have depended on the earth, the water, the air, and the fire: would you preſume

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to inſiſt in your enquiry, Why the conſtituent parts of theſe elements were not ſo many dwarfs?

Confeſs your error, and acknowledge that every being is endued with a perfection ſuited to the ends of its creation. It would ceaſe to anſwer that end, the very moment it ceaſed to be what it is. By changing its nature, it would change its place, and that which it occupied in the univerſal hierarchy ought ſtill to be the reſidence of a being reſembling it, otherwiſe harmony would be deſtroyed.

In the aſſemblage of all the orders of *relative* perfections, conſiſts the *abſolute* perfection of this whole, concerning which God ſaid, *That it was good.*

This immenſe ſyſtem of co-exiſtent and ſucceſſive beings, is no leſs *one* in ſucceſſion than in co-ordination: ſince the firſt link is connected with the laſt by the intermediate ones. Preſent events make way for the moſt diſtant ones. The germ which expanded itſelf in Sarah's womb, was the preparatory cauſe of the exiſtence of a great people and the ſalvation of nations.

3. The heavens declare the glory of God, and the firmament ſheweth his handy-work. That ſublime genius, who expreſſed himſelf with ſuch loftineſs of ſentiment, was nevertheleſs unapprized that the ſtars which he contemplated were in reality ſuns.* He anticipated the times, and firſt ſung that majeſtic hymn, which future and more enlightened ages ſhould chaunt forth to the praiſe of the founder of worlds.

This

* Perhaps ſo.

This aſſemblage of vaſt bodies is divided into different ſyſtems, the number of which perhaps exceeds the grains of ſand, which the ſea caſts on its ſhores.

Each ſyſtem then has its center, either a ſtar or ſun, which ſhines with its own light, and round which revolve various orders of opake globes, that reflect with greater or leſs luſtre the light they borrow from it; which renders them viſible to us.

Theſe globes, which ſeem to *wander* among the heavenly bodies, are thoſe *planets*, the *principal* of which have the ſun for the common center of their periodical revolutions; whilſt the others, which are called *ſecondary*, move round one principal planet, which they accompany like *ſatellites*, in its annual revolution.

Venus and the earth have each of them their ſatellite. One will undoubtedly be ſome time or other diſcovered in Mars. Jupiter has four, Saturn five, and a ring or luminous atmoſphere which ſeems to perform the office of a number of ſmall *moons*: being ſituate ſo far from the ſun, he would have received too faint a light from it, if his ſatellites and ring did not augment it by reflection.

We have diſcovered twenty-ſeven planets, which at preſent compoſe our ſolar ſyſtem; but we are not certain that there are not more. Their number has received a great increaſe by the invention of teleſcopes: more perfect inſtruments, and more accurate obſervers, may probably make farther

farther additions to them. The ſatellite of Venus diſcovered in the laſt century gives room to hope for ſtill greater ſucceſs.

4. The comets alſo are now found to be planetary bodies, whoſe long routes our aſtronomers calculate, foretel their diſtant returns, and determine their place, appearances, and tract. Upwards of thirty of theſe bodies at preſent acknowledge the empire of our ſun, and the orbits which ſome trace round are ſo extenſive, that they do not complete their courſe till the end of a long ſeries of years, and even many ages.

The ſtars are innumerable; and the conſtellations, which antiquity reckoned to be but few in number, amount to thouſands.

If the diameter of the great orbit which our planet deſcribes round the ſun, is more than ſixty millions of leagues, yet this vaſt circumference vaniſhes into nothing, and becomes a mere point, when made uſe of to meaſure the diſtance of the fixed ſtars.

How great then muſt the real bulk of theſe luminous ſpots be, that are perceivable by us at ſuch enormous diſtance! The ſun is ſuppoſed about a million of times greater than the earth, and an hundred and ten times greater than all the planets put together.

5. Whilſt the planets perform theſe revolutions round the ſun, by which the courſe of their years is regulated, they effect another among themſelves, which determines the alternatives of their days and nights.

But

But how do these vast bodies remain suspended in space? What secret power retains them in their orbits, and enables them to circulate with so much regularity and harmony? *Gravity*, that powerful agent, is the universal principle of this equilibrium and these motions. It penetrates in tothe inmost parts of all bodies. By virtue of this force they tend towards each other in a proportion relative to their distance and bulk. So that the planets tend towards the common center of the *system*, and they would be instantly precipitated into it, if the Creator, when he formed them, had not endued them with a *centrifugal* motion, by which they are continually kept at a due distance from the center. Each planet, in constant subserviency to these two forces, describes a *curve* in consequence thereof. By this means the same force which determines the fall of a stone, is the ruling principle of the heavenly motions: wonderful mechanism! whose simplicity and energy give us unceasing tokens of the PROFOUND WISDOM of its AUTHOR.

The globe of earth, which is externally divided into land sand seas, nearly level in their surfaces, is formed within, at least to a certain depth, of *beds* of heterogeneous matter, that are almost parallel, more or less dense, and of a finer or coarser texture.

The surface of the earth abounds with great inequalities. In one part of it we behold vast plains interfected by hills and vallies. In another long chains of mountains, which lift their frozen heads to the clouds; and betwixt them deep vallies. From the bosom of these mountains rivers spring,

ſpring, which after having watered divers countries, and produced ponds and lakes in ſeveral places by enlarging their beds, at length diſcharge themſelves into the ſea, and reſtore to it what it had loſt by evaporation.

6. The ſea preſents us with iſlands ſcattered round its coaſts, with ſands, rocks, currents, gulphs, and ſtorms, and with that regular and admirable motion whereby its waters riſe and fall twice in twenty-four hours.

The lands and ſeas are every where repleniſhed with plants and *animals*, whoſe infinitely varied ſpecies reſort together in every place. Men divided into nations, peoples, and families, cover the ſurface of the globe. They faſhion and enrich it by their various labours, and build habitations from pole to pole, correſponding with their manners, genius, ſoil, climate.

A rare, tranſparent, elaſtic ſubſtance encompaſſes all parts of the earth to a certain height: this ſubſtance is the atmoſphere, the repoſitory for the winds, the immenſe reſervoir of vapours and exhalations, which being ſometimes collected into clouds of a greater or leſſer conſiſtence, adorn our element by their forms and colours, or aſtoniſh us by their flaſhes and violent noiſe; and at other times melting into dews, miſts, rain, ſnow, hail, yield back to the earth what was exhaled from it.

7. The moon, the neareſt to the earth of all the planets, is that we have the beſt knowledge of. Its globe, which is about five and forty times leſs

leſs than ours, always appears to us with the ſame aſpect, becauſe it performs its revolution preciſely in the ſame ſpace of time that it revolves round the earth.

It has its gradual and periodical increaſe and decreaſe of light, according to its poſition with reſpect to the ſun, which enlightens it and to the earth, whereon it reflects the light of that ſun.

The diſk of the moon is externally divided into *luminous* and obſcure parts. The former ſeems analogous to lands on our globe, and the latter to our ſeas.

In the luminous parts there have been obſerved ſome places brighter than the reſt, which caſt a ſhade from their ſide, which has been meaſured, and the tract aſcertained. Theſe parts are mountains much higher than ours, in proportion to the ſize of the moon, and whoſe tops the ſun has been ſeen to gild when that planet is *quartered*; the light deſcending by litttle and little to the foot of theſe mountains, they appear at that time entirely bright. Some are by themſelves, others from very long tracts.

Venus has, like the moon, her ſpots, and mountains. So have Mars and Jupiter. Thoſe in Jupiter form large belts, which make conſiderable motions, like the occan's overflowing the lands, and afterwards leaving them dry on his retreat.

Mercury and Saturn are little known to us; the rſt becauſe it is too near the ſun, the ſecond becauſe it is at too great a diſtance.

Laſtly,

Laſtly, The ſun himſelf has ſpots, which ſeem to move regularly, and whoſe ſize equals, and very often exceeds that of ſuch as are ſeen in the greateſt planets.

8. Pure ſpirits, immaterial and intelligent ſubſtances: extenſive and ſolid ſubſtances; mixed beings, formed by the union of an immaterial ſubſtance and a corporeal; are the three general claſſes of beings which we have any conception of in the univerſe.

In the univerſe all is combination, affinity, connexion. There is nothing but what is the immediate effect of ſomewhat preceding it, and determines the exiſtence of ſomething that ſhould follow it.

The divine mind has ſo cloſely connected every part of his work, that there is not one which has not a relation to the whole ſyſtem. A muſhroom, a mite, are as eſſential parts of it as the cedar or elephant.

So that thoſe minute productions of nature which unthinking men judge to be uſeleſs, are not mere particles of duſt on the wheels of the machine of the world; they are ſmall wheels intermixed with the greater.

There is nothing then by itſelf. Every being has an activity peculiar to it, determined by the rank appointed for it in the univerſe. A mite is a very ſmall moveable creature, which acts in concert with others, whoſe activity extends to much greater diſtances. The ſpheres thus enlarging themſelves more and more, this amazing progreſſion riſes by degrees from the vortex of amber

amber to the ſolar vortex; from the ſphere of a mite to that of an angel.

9. The elements act recriprocally on each other according to certain laws which reſult from their relations; and theſe relations unite them to minerals, plants, animals, and to men. This laſt, as the principal trunk, ſpreads his branches all over the globe.

Theſe ſpecies and individuals have relation to the bigneſs and ſolidity of the earth. The ſolidity and ſize of the earth have relation to the place ſhe occupies in the planetary ſyſtem.

The ſun gravitates on the planets; the planets on the ſun, and on each other. All gravitate on their neighbouring ſyſtems; theſe on more diſtant ones; and the balance of the univerſe remains in equilibrio, in the hands of the ANTIENT OF DAYS.

The human ſoul, by being united to an organized body, maintains an intercourſe with all nature.

From theſe general principles proceeds the connection of cauſes and effects, of effects and cauſes.

From hence alſo ariſes that indiſſoluble union which forms, of paſt, preſent, future, and eternity, one intire individual whole.

The beauty of the world is founded in the harmonious diverſity of the beings that compoſe it, in the number, extent, and quality of their effects, and in the degree of goodneſs ariſing therefrom.

CHAP.

CHAP. II.

Of the relative Perfection of Beings.

1. TERRESTRIAL beings may naturally be ranged under four general classes:

I. Brute and inorganized Beings.

II. Organized and inanimate Beings.

III. Organized and animate Beings.

IV. Organized, animate, and reasonable Beings.

All beings are perfect, considered in themselves; they all answer one end. The determinations or qualities proper for each being, are the means relative to this end. If these determinations should change, they would no longer have a reference to their end, and there would be no more wisdom.

But those means which are of a more exalted nature answer a nobler end. The Being appointed to fulfil this end, is enriched with proportionable faculties.

Beings whose relations to the whole are more varied, more multiplied, and more copious, possess a higher degree of relative perfection.

As there are two general classes of substances, bodies and souls, there are likewise two general classes of perfection, the *corporeal* perfection, or that which is peculiar to bodies; and the *spiritual* perfection, or that which is peculiar to souls.

These two perfections are reunited in every organized animated being, and they correspond with one another.

From

From their reunion proceeds that *mixed* perfection which answers to the rank every being holds in the system.

2. Of all the modifications of matter, the most excellent is organization.

The most perfect organization is that which produces most effects with an equal or smaller number of dissimilar parts. Such amongst terrestial Beings is the human body.

An organ is a system of solids, whose structure, arrangement, and action, have motion for their ultimate end, either intestine or loco-motive, or feeling.

A Being, which is barely formed by a repetition of similar parts, enjoys the lowest degrees of corporeal perfection. Such probably is the *atom* or *elementary particle.*

The faculty of generalizing ideas, or abstracting from a subject what it has in common with others, and expressing it by arbitrary signs, constitutes the highest degree of spiritual perfection; and therein consists the difference between the human soul and the soul of brutes.

The soul which is only endued with sense occupies the lowest degree in the scale. This perhaps is the perfection of the soul of the muscle.

3. The reciprocal action of solids and fluids is the foundation of the terrestrial life.

To nourish ourselves, to *grow* by our food, to beget individuals of our own species, are the principal ends of the terrestrial life.

If the action of the organs is not accompanied with a sense of this action, the organized being enjoys only a *vegetative* life. Such is the case of the *plant*.

If the action of the organs is joined with a sense of that action, the organized Being enjoys a *vegetative* and *sensitive* life. This is the condition of the *brute*.

Finally, if reflection is joined to feeling, the Being enjoys at the same time a *vegetative, sensitive* and *reflective* life. 'Tis man alone, upon earth, that unites these three kinds of life in himself.

The corporeal and intellectual faculties may be carried to so high a pitch of perfection, in the most exalted order of mixed Beings, that we are able to form but faint ideas of then.

4. Between the lowest and highest degree of corporeal and spiritual perfection, there is an almost infinite number of intermediate degrees. The result of these degrees composes the *universal chain*. This unites all beings, connects all worlds, comprehends all the spheres. One SOLE BEING is out of this chain, and that is HE that made it.

A thick cloud conceals from our sight the noblest parts of this immense chain, and admits us only to a slight view of some ill-connected links, which are broken, and greatly differing from the natural order.

We behold its winding course on the surface of our globe, see it pierce into its entrails, penetrate into the abyss of the sea, dart itself into the atmosphere, sink far into the celestial spaces, where we are only able to descry it by the flashes of fire it emits hither and thither.

But

But notwithſtanding our knowledge of the chain of Beings is ſo very imperfect, it is ſufficient at leaſt to inſpire us with the moſt exalted ideas of that amazing and noble progreſſion and variety which reign in the univerſe.

5. There are no ſudden changes in nature; all is gradual, and elegantly varied. There is no being which has not either above or beneath it ſome that reſemble it in certain characters, and differ from it in others.

Amongſt theſe characters which diſtinguiſh Beings, we diſcover ſome that are more or leſs general. Whence we derive our diſtributions into claſſes, genera, and ſpecies. But there are always between two claſſes, and two like genera, *mean* productions, which ſeem not to belong more to one than to the other, but to connect them both.

The polypus links the vegetable to the animal. The flying ſquirrel unites the birds to the quadruped. The ape bears affinity to the quadruped and the man.

But if there is nothing cut off in nature, it is evident that the diſtributions we make are not her's. Thoſe we form are purely nominal, relative to our neceſſities and the bounds of our knowledge. Thoſe intelligences which are ſuperior to us, diſcover perhaps more varieties between two individuals which we range under the ſame ſpecies, than we do between two individuals of diſtant genera.

So that theſe intelligences ſee the ſcale of Beings all compoſing one ſingle conſequence, which has for its firſt term an atom, and for it laſts the moſt exalted ſeraph.

We may then ſuppoſe in the ſcale of our globe as many ſteps as we know there are ſpecies. The eighteen or twenty thouſand ſpecies of plants which compoſe our herbals, are therefore eighteen or twenty thouſand ſteps of this celeſtial ladder.

And there is not a ſingle plant amongſt theſe, which does not perhaps nouriſh one or more ſpecies of animals. Theſe animals harbour or provide nouriſhment for others in their turn. They are ſo many little worlds comprized in others that are ſtill ſmaller.

Simple produces compound. The molecule forms the fibre, the fibre the veſſel, the veſſel the organ, the organ the body.

The ſcale of nature then is conſtructed by paſſing from that which compoſes it, to that which is compoſed by it, from the leſs perfect to the greater.

But while we view it in this light, and in a very general manner, we are not to forget that our method of conception is not the rule of things. We are only to take a tranſient ſurvey of the exterior parts of Beings.

CHAP.

CHAP. II.

General view of the gradual progression of Beings.

1. FROM the immutability of species amidst the perpetual motion that reigns in the universe, is deduced the indivisibility of the first principles of bodies: and the indivisibility of these principles would demonstrate the simplicity of their nature, if God had not power to render the highly compounded particles incapable of separation.

The nature of elementary atoms, their forms, relative proportions, and the manner whereby they effect the formations of bodies, are branches of knowledge that surpass the reach of the human mind.

So that we cannot determine whether there are as many species of elements as of bodies; or whether the same elementary particles, variously combined, give birth to different compounded species.

We are likewise ignorant what it is that essentially distinguishes one body from every other; those we call *essential characters*, are only the ultimate result of the first principles.

O how interesting would the sight be, were we permitted to penetrate into these principles! A new world would disclose itself to our view; nature then become tranſparent, would no longer conceal her way from us: her laboratories and workſhops would then be thrown open. Here we ſhould ſee her collecting the principles of metals; there behold her preparing the colour of the roſe. Farther, we might trace her footſteps into the wonders of light and electricity. In other places ſhould obſerve her ſketching the out-lines of a plant or animal. Aſtoniſhed at the ſight of this admirable work we ſhould never be weary of contemplating the infinite diverſity of preparations, combinations, and motions, by which it is inſenſibly brought to its perfection.

Ye celeſtial ſpirits who aſſiſted at the creation of our world, you enjoy theſe pleaſures! Being more favoured than us by the MASTER of nature, you penetrate into what eſcapes our notice, and ſee with what difficulty we creep from one truth to another, as we obſerve the efforts of an ape to imitate a man.

2. Obſerve three principal kinds of compoſitions in terreſtrial bodies. 1. That of *fluids*. 2. That of *rude* or *un-organized ſolids*. 3. That of *organized ſolids*.

The firſt genus, which is the moſt ſimple, ſeems to conſiſt in a bare contact of homogeneous particles, which tend towards each other; but the leaſt force divides them.

The ſecond, which is more compounded, is formed of the union of different particles into a ſolid maſs.

3. The

The third, ſtill more compounded, is formed of the intermixture of an infinite number of parts, ſome fluid, and others ſolid.

3. The ſmall reſiſtance which fluids make to the force that divides them, their inclination to a level, the quickneſs and eaſe wherewith they move, penetrate, and ſeparate ſolids, ſerve to indicate that they are of all bodies the moſt ſimple, ſubtle and active.

Fire ſeems to be a fluid which unites theſe qualities in the moſt eminent degree. It is evident from a number of experiments, and particularly from thoſe made by *electricity*, that fire is a fluid diffuſed into all bodies, in various proportions. Sometimes it barely fills their pores; at others, is intimately united to their conſtituent parts, and compoſes inflammatory matter.

Air and *water* are likewiſe contained in the compoſition of a prodigious number of matters of different kinds. Sometimes they ſeem to change their nature, and to undergo various transformations; but theſe transformations are only imaginary. They reſume their primitive ſtate, as ſoon as the cauſes which obſcured them ceaſe to act.

4. Pure earth is the baſe or foundation in the compoſition of ſolids. The chemiſt meets with it in every body he analyſes. Being fixed and unalterable, it will reſiſt the moſt violent fire; and this immutability of elementary earth, by convincing us of the ſimplicity of its nature, ſhews likewiſe that it is the firſt ſtep of the ſcale of inactive ſolids.

From a mixture of pure earth with oils, ſulphurs, ſalts, &c. proceed the various ſpecies of more or leſs compounded earths, which are the proper nouriſhment of one part of organized bodies.

Bitumens and *ſulphurs*, which are chiefly formed of inflammable matter and earth, ſeem to lead us from pure earth to metallic ſubſtances, in which we diſcover the ſame eſſential principles, only differently combined.

The inalterability of gold from the moſt violent fire, its maleability, and prodigious ductility, equally prove the homogeneouſneſs, extreme fineneſs, and ſtrict union of its parts.

Other metals are ranged after gold, according to the order of their compoſition, or the ſtronger or weaker combination of their principles. Platina immediately follows gold: and ſilver that. Silver alſo reſiſts the action of fire; but is leſs malleable and ductile than gold, and diſſoluble by a much greater number of diſſolvents.

Copper appears after ſilver, and has a great affinity to that metal. It is itſelf ſucceeded by tin, lead, and iron.

Thoſe compounds, which differ from metals only by their not being malleable, bear a great reſemblance to them, and are called *demi-metals*. Such are *antimony*, *biſmuth*, *ſpelter*.

Vitriols, produced by the union of metallic particles with a coagulated acid, ſeem to be the paſſage from metallic ſubſtances to *ſalts*.

Salts

Salts, which always affect determinate and constant figures, indicate thereby the invariableness and simplicity of their principles, whose fundamentals are water and earth.

When they are dissolved by water, or volatilized by air, they become one of the principal causes of the growth of vegetables, as they are of *fermentations*, whose effects are so various and extensive.

The regularity and uniformity of the different kinds of chrystallization, sufficiently prove that they are to be attributed to salts, which being dissolved and conveyed by a liquid, and united to foreign matters, compose these pyramidal masses.

Stones, whose species are so numerous, present us with masses of every form, colour, size, and consistence, according to the diversity of liquids, earth, sulphur, metallic parts, salts, places, and other circumstances which contributed to their formation.

Some of them are perfectly transparent; and these seem to be the most simple. Others are more or less opake, as their principles are more or less heterogeneous, or more or less mixed.

5. The apparent *organization* of *leafed* stones, or such as are divided into layers, as slates, that of fibrous stones, or those composed of filaments, as the amianthus, seem to constitute the passage from rough to organized solids.

We must however allow, that this transition is not so happily effected, as those we observe in divers other classes of terrestrial beings.

Organized ſolids are divided into two general claſſes; *vegetable* and *animal.*

It is not eaſy to determine preciſely the diſtinction between theſe two claſſes. We cannot clearly diſcern where the vegetable terminates, or the animal commences.

Neither the greater or leſs degree of ſimplicity in organization, nor the method of production, nouriſhing, increaſing and multiplying, nor the *locomotive* faculty, ſufficiently enables us to diſtinguiſh between theſe two orders of beings.

There are ſome animals whoſe ſtructure appears as ſimple as that of plants.

What the ſeed and germ are to the plant, the egg and embryo are to the animal.

The plant and animal increaſe in equal proportion by an inſenſible expanſion occaſioned by nutrition.

The matter received in both of them by inward ſuſception, is there ſubject to analogous preparations. One part ſerves as a cloathing to the eſſence of the plant or animal; the reſt is evacuated.

There is in plants as well as animals a diſtinction of ſexes; and this diſtinction in them is followed by the ſame eſſential effects that accompany the latter. Several kinds of animals multiply by ſlips and ſprigs; and there are ſome, that, like plants, paſs their whole lives without changing their ſituation.

If there is any one character, peculiar to the animal, it is that of being furniſhed with nerves.

6. The

6. The plant which ſeems to occupy the loweſt place in the ſcale of vegetables, is a ſmall unformed maſs, in which the eye can only perceive a kind of marbling, without any diſtinct part. This plant is the truffle, the ſeeds of which are diſcovered by the microſcope.

At a ſmall diſtance from theſe, is the numerous family of muſhrooms and agarics, which would be taken for different kinds of excreſcences, were it not that the eye, by the aſſiſtance of a glaſs, can diſcover flowers and ſeeds in their folds or cavities.

Liverworts, equal in the number of their ſpecies to muſhrooms, nearly reſemble them. They cleave to the ſurface of ſtones, dry wood, trees, &c. ſometimes like brown ſpots, at others in pieces of a circular form, of a grey, or yellow colour, compoſed of ſmall ſhells or nobs, or notched like fringe, lace, &c. The ſeeds are contained in ſmall capſules, inviſible to the naked eye, as are likewiſe the flowers.

Moſſes ſeem to be a ſpecies between the muſhrooms and liverworts. They delight in ſhade and moiſture, and cling to various ſorts of bodies. The filaments which iſſue from them are often of a cotton-like nature, and bear flowers and ſeeds.

7. Plants are of three very diſtinct ſorts.

The firſt, which are for the moſt part of a ſmall ſize, delicate conſtitution, inactive, and abounding in humours, live but a ſhort time; a year is commonly the term of their life.

The ſecond, which are for the moſt part of a gigantic ſize, robuſt conſtitution, hard, and not ſo full of humours, live many years, and even for ſeveral ages.

The third bear a mean proportion between the firſt and ſecond.

Herbs are the firſt, *trees* the ſecond, and *ſhrubs* the third.

Theſe three kinds which are ſpread over the face of the earth, live promiſcuouſly therein; but there exiſts in the different claſſes, an almoſt infinite diverſity of ſizes, forms, colours, and inclinations.

They all in common paſs their lives in a ſtate of immoveableneſs. Fixed to the earth by various ſorts of fibres, they derive their principal nouriſhment from it; and with them, to live is to expand themſelves.

8. The *roots*, *ſtalk*, *branches*, *leaves*, *flowers*, and *fruits*, comprize all that is moſt remarkable in the external parts of plants.

The *roots*, by means of their different kinds of *hinges*, *tuberoſities*, and *ramifications*, keep the plant fixed to the earth, while their pores imbibe an exceeding fine ſlime, which the water liquefies, and carries with it.

From the root ſprings the ſtalk, to which the plant partly owes its ſtrength and beauty. Being ſometimes ſhaped like a pipe; it is fortified with knots ſkilfully diſpoſed. As it is ſometimes too weak to ſupport itſelf, it contrives means to twiſt itſelf about a ſolid prop, or to faſten to it by means of the little *hands* it is furniſhed with. Otherwiſe it appears a ſtrong pillar, bears its proud head

head aloft in the air, and braves the efforts of ftorms and tempefts.

The *branches* fhoot forth, like fo many arms, from the trunk and ftalk, on which they are diftributed with great regularity. They are divided and fub-divided into many fmall boughs, and the fub-divifions obferve the fame order as the principal divifions.

The *leaves*, that charming ornament of plants, are difpofed round the ftalk and branches with the fame fymmetry. Some are *fimple*, others *compounded*; or formed of various foliage. One fort is plain; another indented. Some of them are very thin, others hard, foft, plump, fmooth, rough, or hairy.

The *flowers*, whofe enamel is one of the principal beauties of nature, are not lefs diverfified than the leaves. Some have only a fingle leaf, others feveral. Here it appears like a large veffel opening itfelf gracefully; there it forms a grotefque figure in imitation of a muzzle, head piece or cowl. Farther ftill, it is a butterfly, a ftar, a crown, a radiant fun. Some are difperfed on the plant without any art; others compofe nofegays, globes, tufts of feathers, garlands, pyramids.

The greater part of them are furnifhed with one or more cups, fometimes fimple and plain, at others confifting of feveral pieces, or properly cut.

From the center of the flower proceeds one or feveral little pillars, either fmooth or channelled, rounded at top, or terminating in a point, called *piſtils*, which commonly encompaſs other ſmaller pillars called *ſtamina*. Theſe carry on the upper part of them a ſort of ſmall bladders full of exceeding fine powder, every grain of which, viewed through a microſcope, appears of a very regular figure, but varied, according to his ſpecies. In ſome they are ſmall ſmooth globes; in others, they are thick ſet with prickles like the covering of a cheſnut, and ſometimes they reſemble ſmall priſms, or ſome other regular body.

But how ſhall we expreſs their fineneſs, the lively appearance, delicacy, and variety of ſhadowings, which accompany, in many ſpecies of flowers, the ſweetneſs and agreeableneſs of the perfume?

The flowers are ſucceeded by the *fruits* and ſeeds. Magnificent decoration! precious riches, which repair the loſſes occaſioned to plants by the intemperateneſs of ſeaſons, and the neceſſities of men and other animals.

All fruits and ſeeds have this in common, they incloſe under one or more coverings the germ of the future plants. Some have only ſuch coverings as immediately infold the germ, whoſe outſide is of the ſtrongeſt contexture; and among theſe, there are ſome that are provided with wings, tufts, or plumes of feathers, by means of which they are conveyed in the air or water, by which they are tranſported and ſown in different parts. Others are better cloathed, being lodged in ſheaths or pods, incloſed in a kind of box, having one or more partitions. A third ſort, under a moſt delicious fruit, which is rendered ſtill more agreeable

by

by its beautiful colour, contain a ſtone or kernel. Others are incloſed in ſhells which are either armed with prickles, abound with a bitter juice or adorned with very fine hair.

The outſide of fruits and ſeeds do not afford leſs variety than the leaves and flowers; there is hardly any figure whatever which they do not furniſh a repreſentation of.

9. The inſide of plants is compoſed of four orders of veſſels, viz. the *ligneous fibres*, *utriculi*, or *little bags*, the *proper vaſes*, and the *trachea* or *air-veſſels*.

The *ligneous fibres* are very ſmall channels depoſited according to the length of the plant, and conſiſt of little pipes placed near each other. Sometimes theſe veſſels are parallel, and at others are ſeparated, leaving between them intervals or oblong ſpaces.

Theſe ſpaces are filled by the *utriculi*, a kind of membranous bladders, horizontally diſpoſed, and which communicate with each other.

The *proper vaſes* are a kind of ligneous fibres which principally differ from the reſt by their juice, which is of a deeper colour, or thicker.

In the middle of them, or round a great number of ligneous fibres, are ſome veſſels which are not ſo narrow, compoſed of a ſilvery elaſtic blade, formed ſpirewiſe, like a ſpring; theſe are *arteries*. They ſeldom contain any thing but air.

Theſe four orders of veſſels, which are diſperſed through all the parts of the vegetable in proportion

tion to the functions of each, compose, at least in trees and shrubs, three principal beds. the *bark*, the *wood*, and the *pith*.

The *bark*, or *rind*, which is the outer covering of plants, and is smooth, even, and shining in some, and rough, channelled, and hairy in others, is formed of the widest fibres that are the least pressed together, and which admit within them the most air.

The *wood*, which is placed under the rind, has narrower and more contracted pipes, its utricles less replenished or dilated; and this only has arteries.

The *pith*, which is situated at the heart of the plant, is little more than a collection of utricles, which are greater and more capacious than those of the bark and wood. They diminish, and dry up, as the plant advances in age.

The simplicity of the organization of vegetables is the principal source of their different methods of multiplication.

A plant pushes out buds from all points of its surface, these buds themselves are plants: being cut, and laid in the ground, they take root there, and become intire plants, like that of which they were before only a part.

The smallest branch or leaf may give birth to such a whole plant.

Suckers taken from different plants, and ingrafted in the stalk or branches of another plant, incorporate

incorporate themſelves with it, and being united thereto, form one organical body.

10. The timorous *ſenſitive* plant flies the hand that approaches her; ſhe cloſes herſelf again with the utmoſt ſpeed; and this motion bearing ſo great a reſemblance to that of animals, ſeems to conſtitute one of thoſe connections whereby the *vegetable* and *animal kingdoms* are united.

A little above the ſenſitive, in a kind of calix, at the bottom of the water, is a ſmall body, exactly reſembling a flower. It draws back and entirely diſappears when I offer to touch it. It comes out of the calix, and opens itſelf on my retiring to a diſtance from it.

While I was endeavouring in vain to account for this, I diſcovered by the ſide of it another body of the ſame form, but larger, and not lodged in an incloſure. It was ſupported by a ſmall ſtalk, whoſe lower extremity joined to a plant, whilſt the other, inclining towards the ground, was divided into ſeveral little branches.

I immediately believed it to be a *paraſite* plant; and in order to be more fully convinced of it, I cut it in half between its two extremities.

It ſoon ſprouted out again, and appeared the ſame as before. I ſtood awhile to conſider it. I ſaw the little branches move, and extend themſelves to ſeveral inches in length. They are extremely fine, and ſpread themſelves on all ſides.

A little worm came and touched one of theſe branches: it preſently twiſted itſelf about the worm, and by contracting itſelf, brought it to the upper

upper extremity of the ſtalk. There I perceived a ſmall aperture, which enlarged itſelf in order to receive the worm. It was received into a long cavity that incloſes the ſtalk: being there diſſolved and digeſted before my eyes; I afterwards ſaw the remainder go out again at the ſame opening.

The next moment, this ſingular production ſeparated itſelf from the plant, and began to walk. The branches after having performed the office of arms, are likewiſe employed by it inſtead of legs.

After having made theſe obſervations, I could not help acknowledging, that what I took for a paraſite plant, was a real animal. I then took a view of the piece I had cut off from it, and perceived, to my ſurprize, that it had grown, and was become a compleat one like the other.

But my ſurprize was greatly increaſed, when at the end of ſome weeks I found theſe animals were transformed into two ſmall very buſhy trees.

From the trunk, which I knew to be the body of the animal, ſprung ſeveral branches on all ſides of it; from theſe branches, ſmaller ones ſprouted forth, and from thoſe, ſmaller ſtill. They all move different ways, and ſtretch out their branches, while the trunk continues fixed to a prop. This ſurprizing aſſemblage forms only one entire body; and the nouriſhment it receives by one of its parts, is ſucceſſively communicated to all the reſt. In ſhort, this collection of bodies divides itſelf; each piece ſeparates itſelf from the others, and lives diſtinctly from them.

Amazed at theſe wonders, I part one of theſe animals length-wiſe, about the middle of the body,

I am

I am presently in possession of a monster with two heads.

I repeat the operation a great many times on the same subject, and by this means I give birth to an hydra, more astonishing than that of *Lerna*.

I part several of these animals transversely, and lay the separated pieces end to end. They graft or unite themselves to each other, and compose only one intire animal.

To this prodigy I find a new one succeed. I turn one of these insects, as we do a glove, putting the outside within, and *vice versa*. He does not suffer the least alteration from that: he lives, grows, and multiplies.

These animals which multiply by slips and shoots, that we ingraft and turn inside out, are polypus's.

They are of very different species. Many of them never shift their place. Some divide themselves length-wise, and thus make very pretty nosegays, whose flowers are in clusters.

11. There is a wonderful variety in the construction of animal machines. There are some whose number of parts is very small; others on the contrary, are very much compounded. In some there are only two or three pieces alike; others exhibit to us a much greater number. In short, the same parts are differently disposed or combined in different machines.

The perfection of the machines in nature consists, as in those of art, in the number of parts, and diversity of effects. That is accounted the most perfect, which with the smallest number of parts, produces the greatest variety of effects.

But

But there is, with respect to ourselves, a considerable difference between the natural and artificial machines; for whereas we may judge of these by an exact comparison of their strength and produce, we can only form our opinion of the others by their consequences.

After this manner we are enabled to judge of the perfection of the human body, from the diversity and extent of the operations of man, rather than from an inspection of his organs, of which we have only a partial view. And if corporeal perfection corresponds with spiritual, as there is reason to believe it does, man, as he is superior to other animals by understanding, so he likewise is by organization. Whence we may infer, that those animals, whose structure most nearly resembles that of men, ought to be considered as the most elevated in the scale.

12. Of all animals that are known to us, the polypus is one whose structure seems to be the most simple, and to come nearest that of plants. This extraordinary animal seems to consist altogether of stomach. His body and arms are composed of one and the same bowel, whose composition is perfectly uniform. The best microscopes only discover in them an infinite number of small grains, which are tinged with the nourishment the animal feeds upon?

Can these grains be so many utricles? Can they receive the aliment by immediate conduits, prepare it and transmit it to other vessels appointed to convey it into the channels of circulation? Is there a circulation in the polypus?

The

The different kinds of veſſels which the firſt conjecture ſuppoſes, and which their fineneſs or tranſparency may render inviſible to us, muſt be lodged in the thick part of the texture of the polypus. We are induced to think ſo from the experiment of turning it inſide out, which being effected, does not cauſe any change in the vital functions.

But of what ſervice can that property be to the polypus, which it cannot make uſe of without the aſſiſtance of man? I mean the operation of turning the inſide outwards.

I anſwer, that this property is one of the conſequences of an organization peculiarly neceſſary to the polypus. The Author of nature never intended to create an animal capable of being turned as we do a glove: but he deſigned to form an animal whoſe principal viſcera were lodged in the thickeſt part of the ſkin, and which had power in a certain degree to eſcape various accidents to which the nature of its life unavoidably expoſed it. Now, what naturally follows from this organization is, the being enabled to endure this ſhifting without occaſioning its death.

13. Thoſe animals whoſe ſtructure appears leſs ſimple than that of the polypus, multiply like him by ſlips.

Theſe *worms*, which have a ſtomach, inteſtines heart, arteries, veins, lungs, and organs of generation. If we look narrowly into the circulation of their blood, we ſhall perceive its continuance with the ſame regularity in all thoſe parts which have been ſeparated from the reſt by cutting.

Theſe

These worms bring us to treat of *insects*.

14. Here we are introduced into a kingdom of *animals*, the most extensive and diversified of any on the face of the globe. That province of this vast empire which is seen on the surface of vegetables, is sufficient of itself to attract the curiosity of a traveller, either from the prodigious number of its inhabitants, or the singularity and diversity of their forms.

These are pigmies, the greatest part of which are so minute, as not to be distinctly seen without the help of a microscope. They bear the general name of *Insects*, and this name was given to them on account of the *incisions* of various depths, by which the bodies of several of them are divided.

The character which seems essentially to distinguish insects from other animals, is, that they have no bones. The analogous parts with which some species of them are provided, are placed on the outside of their bodies, whereas in other animals the bones are always on the inside.

Life, in insects, does not result from a mechanism as compounded, as in the animals of a larger size. In them, the number of different kinds of organs is smaller: but some of these organs seem more multiplied.

Considered in their exterior form, insects may be divided into two classes. The first comprehends insects *improperly so called*, whose body is continued; these bear the general name of worms. The second class comprehends insects properly so ſo termed, whoſe body is divided by certain inciſions or contractions.

In the greater part of inſects of this claſs, the inciſions ſeparate the body into three principal parts, the *head*, the *ſtomach*, the *belly:* this diviſion has a relation to that obſerved in great animals. Some of the inſects of the firſt claſs are without legs: others are furniſhed with them. All the inſects of the ſecond claſs have legs; but ſome are winged, others not.

There is ſuch a diverſity in inſects, that it may be queſtioned if there is not united in them every variety to be met with throughout the animal world. And what renders this variety ſtill more ſurprizing is, that it does not extend merely to the whole ſpecies, but likewiſe to individuals. The ſame inſect has at one time organs that are not to be found in him at another. The ſame individual which in his youth belonged to the firſt claſs, in a more advanced age take up his rank in the ſecond. From thence ariſe the difficulties attending a proper diſtribution of theſe little animals.

15. The bodies of almoſt all inſects are formed of a collection of *rings*, ſet in each other, which by contracting or dilating, lengthening or ſhortening, contribute to all the motions of the animal.

The *head*, in many ſpecies changes its form in an inſtant. It contracts and dilates itſelf, lengthens and ſhortens, appears and diſappears, at the pleaſure of the inſect. The flexibility of its folds enables it to make theſe motions. In other ſpecies, he head is in one conſtant poſition, and bears a greater

greater resemblance to that of the larger animals by the hardness of its covering, which is scaly.

The *mouth* is sometimes discovered to be a simple circular aperture: but it is generally furnished with hooks, or a kind of pick-ax; with *teeth*, or two indented shells which they move horizontally; with a *trunk*, a very compact instrument, which serves to extract and liquefy, and raise up alimentary juice; or with a sting, which is an organ analogous to the trunk, and endued with the same essential functions,

Several species have two of those instruments united in them, sometimes the teeth and the trunk, and sometimes the trunk and the sting. Many species of insects are deprived of the use of sight. With them the feeling or some other sense, supplies the defects of eyes.

The eyes of insects are of two kinds; the *smooth* ones are always few in number; the *rough* commonly amount to several thousands, and are fixed on the sides of the head, in the form of two semicircular masses. In both of them they are utterly immoveable; and their number compensates in some measure the want of mobility: it is therefore less a mark of perfection than of imperfection. Many species have at the same time two smooth eyes and two rough ones.

Hearing seems to be denied to insects: at least the existence of this sense in them is very doubtful.

The case is not the same with respect to smelling. Divers insects have it in an exquisite manner,

ner, but the ſeat of it is not known. May it not be ſituate in thoſe two moveable horns called the antennæ, whoſe uſe we are yet unacquainted with ?

The *legs* of inſects are *ſcaly* and *membraneous*. Thoſe are moved by the aſſiſtance of divers articulations, while theſe, which are more pliable, are turned every way without difficulty. Theſe two ſorts of legs are often united in the ſame worm. Some of them have ſeveral hundred legs; but do not on that account walk faſter than ſuch as have only ſix.

The *wings*, which are two or four in number, are ſometimes formed of a ſimple and more or leſs tranſparent gauze, and ſometimes covered with little ſcales differently figured; in ſome they are compoſed of feathers, as in birds, in others they are uncovered, or incloſed in caſes. In many ſpecies the male is winged, and the female not.

On the ſides or extremities of the body are little oval apertures, ſhaped like the ball of the eye, and ſuſceptible of the ſame motions. Theſe are ſo many mouths for the purpoſe of reſpiration.

16. The interior part of inſects contains four principal viſcera; the ſpinal marrow, the *inteſtinal bag*, the heart and the tracheal arteries.

A blackiſh thread, which is extended the whole length of the belly from the head to the hinder part, and knit together at certain diſtances, is the the *ſpinal marrow* of inſects, or the principal trunk of the *nerves*.

The *knots* placed from one ſpace to another, ſeem ſo many particular *brains*, appointed to diſtribute

tribute the nervous ſtrings to the neighbouring parts, from the action of which the feeling and motion proceed. The firſt of theſe knots conſtitutes the *brain*, properly ſo called.

On the medullary thread is placed the *inteſtinal bag*, which is equal to it in length. It is a long gut, in which are contained the *œſophagus*, *the ſtomach*, and *inteſtines*,

Along the back, and parallel to the inteſtinal bag, there runs a long and thin veſſel, in which may be perceived, through the ſkin of the inſect, alternate contractions and dilatations. This is the heart, or that part which performs the functions of it.

The arterial veſſels of inſects perfectly reſemble thoſe of plants. There is in every part of them the ſame ſtructure, colour, elaſticity, deſtination, and diſperſion through the whole body.

17. Worms, whoſe bodies are lodged in a cruſtaceous or ſtony pipe, ſeem to conſtitute the connection between inſects and ſhell-fiſh.

There are notwithſtanding ſome ſhell animals, whoſe ſtructure with reſpect to its ſimplicity, ſeems to vie with that of the polypus.

Of this number is the *pond muſcle*, wherein we can diſcover neither ſpinal marrow, arteries, veins, nor lungs.

Does the ſcale of nature branch out as it advances? May inſects and ſhell-fiſh be two paralle branches of this great ſtem? May the *frog* and the *lizard*, which bear ſo near a reſemblance to inſects, be a ramification of them? We are not able at preſent to anſwer theſe queſtions.

Such is the gradation between beings, that they often differ from each other by ſlender ſhadowing;

ings; and ſuch is the narrowneſs of our capacities, that none but the plain and more ſtriking marks attract our notice.

18. The agreeable diverſity in the figures of ſhells, helps us to judge of the variety ſubſiſting in the organization of thoſe animals who are the inhabitants and architects of them. Some conſiſt of one intire piece; others of two or more. Some are formed in imitation of a *trumpet*, a *ſcrew*, a *tiara*, a *dial*. Others reſemble a *helmet*, a *club*, a *ſpider*, a *comb*. In this, it is a kind of fleſhy caſe; in another it is a ſhip, wherein the ſailor is at the ſame time rudder, maſt, and ſail.

Animals that have ſhells, and inſects with ſcales, ſeem to have an affinity to each other by a common character; both of them have their bones placed on the outſide. We may in effect conſider the ſhell as the bone of the animal which occupies it; ſince he brings it into the world with him, and adheres to it by different muſcles.

But it is certain, moſt ſhells are formed of the ſtony juices, which tranſude from the pores of the animal.

The bones, as well as the ſhells of inſects, grow and are nouriſhed by veſſels which paſs through their ſubſtance.

Shell-fiſh form two great families, that of the *conchæ*, or larger kind, whoſe ſhell is made up of two or ſeveral pieces; and that of *ſnails*, whoſe ſhell conſiſts of one ſingle piece, turned for the moſt part ſpirally.

The ſtructure of the firſt ſeems much more ſimple than that of the laſt. The conchæ have neither head, horns, nor jaws; one can only observe in them air-vents, a mouth, an anus, and sometimes a sort of foot. The greatest part of *snails*, on the contrary, have a head, horns, eyes, a mouth, an anus, and a foot. The round and fleshy *head* is at the anterior and upper part of the animal. It contains a brain, composed of two little globes, whose apparatus is of such a moveable nature, that it is transferred from the hinder to the fore part at the pleasure of the snail. The *horns*, which are two or four in number, placed on the sides of the head, are a kind of pipes, susceptible of various motions, and which the animal can draw into his head by the help of a muscle, which the Grand Observer has ordained to perform the functions of the *optic nerve*. In some species of snails the *eyes* are placed at the extremity of the horns, as at the end of the shank of a pair of spectacles. In others at the base, or towards the middle. They are black and brilliant, pretty much resembling the form of a very small onion. We can only discover their *tunic*, which is called the *uvea*; but they have the three humours belonging to our eye. The *mouth*, which is commonly a small chink like a furrow, is furnished in many species of them, with two cartilaginous jaws placed on each other, whose inequalities or clefts perform the office of *teeth*, some species have real teeth, like those of a sea-dog, which are extremely small.

The shell-fish that have no jaws, have a fleshy or muscular pipe, which supplies the place of a *snout*.

Snails are not provided with feet; but they have one foot of a particular make, which is nothing more

more than a collection of a great number of muscles, whose motions imitate those of the waves of the sea. A pretty thin membrane lines the inside of the shell, and sometimes the outside. It is a kind of *mantle*, furnished with trachea or air-vents, which separate the air from the water, at the origin of which are perceived little *gills* destined to the same uses. The *heart*, which is situated near the surface of the body, has a sensible motion, whereby it rises and falls alternately. In the conchæ it is underneath the stomach.

19. Animals with shells bear an affinity to fishes. *Reptiles* seem to take place between or next to them, being united to shelled animals by the *slug*, and to the fishes by the *water-serpent*.

In reptiles, animal perfection begins to increase in a sensible manner. The number of their organs, their confirmation and exercise, give them on this account a greater analogy with the mechanism of those animals we esteem the most perfect. The organs of vision, hearing, and circulation, furnish examples sufficient to indicate this. This analogy is augmented in fishes.

The *eel*, by its formation, and *creeping fishes* by their method of moving, connect fishes with the water-serpent.

20. Fish are like reptiles, for the most part covered with *scales*, whose figures and rich colours help to make a distinction between the species.

There is a great variety in the form of fishes. Some are long and slender; others are broad and

 short.

ſhort. We ſee among them flat, cylindrical, triangular, ſquare, and circular. Some are armed with a great *horn*. Others wear a long *ſword*, or a kind of *ſaw*. A third ſort are furniſhed with *pipes*, through which they throw out the remainder of the water they have ſwallowed. Wings are to birds of the ſame uſe as *fins* to fiſhes. Some have two or three: others have a greater number. The *head* of fiſhes, like that of reptiles, is joined cloſe to the body. The mouth, which is commonly furniſhed with two or more rows of teeth, is ſometimes placed on the back, as are the eyes. The *lungs*, which are formed of ſeveral blades or vaſcular leaves, are often placed at the ſurface of the body. They are known by the name of *gills*. But let us avoid anatomical deſcriptions, which would carry us too far. We ſhall now confine ourſelves to ſome of the principal varieties, and to the ſources of thoſe relations that are moſt ſtriking.

21. I ſee the flying fiſh dart itſelf into the air from the bottom of the water, having fins reſembling the wings of a bat. Herein it has an affinity to birds. But I ſee a great animal advancing towards the ſea-ſhore, having a head and fore-part like a lion, and the hind-part reſembling that of a fiſh. It has no ſcales: and is borne on two paws that have toes with fins to them. 'Tis called the *ſea-lion*. He is followed by the *ſea-calf*, and the *hippopotamus* or ſea-horſe, and by all in general of the *cetaceous* kind. The *crocodile* and *tortoiſe* preſent themſelves to my view in their turn; and I now find myſelf among quadrupeds. Without preſuming to account for the ways of nature, we will at preſent place birds between fiſhes and four-

footed

footed animals. In this order *aquatic* birds are ranged immediately under the flying-fish. *Amphibious* birds, or such as live both on land and in the water, will occupy the scale next in course, and by this means open a communication between the terrestrial, aquatic, and aërial regions.

To this new mansion there is added a new decoration. To scales succeed feathers, which are closer compacted and more varied: a bill takes place of teeth: wings and feet are to them instead of fins: lungs formed within, and of a different structure, cause the gills to disappear: a melodious song follows a profound silence. Between the *cormorant* and *swallow*, the *partridge* and *vulture*, the *humming bird* and *ostrich*, the *owl* and *peacock*, the *raven* and *nightingale*, what a surprizing variety is there of structure, proportion, colour, and song!

22. Hairy birds having projecting ears, a mouth furnished with teeth, and whose body is carried on four paws armed with claws, are they birds in reality? Are quadrupeds, that fly by the assistance of great membraneous wings, really such? The *bat* and *flying-squirrel* are these strange animals, which are so proper for establishing the gradation that subsists between all the productions of nature. The ostrich, with the feet of a goat, which rather runs than flies, seems to be another link which unites birds to quadrupeds.

The class of quadrupeds is not inferior in variety to that of birds. These are two perspectives of a different taste, but which have some analogous points of view. *Carnivorous* quadrupeds answer to birds of *prey*. Quadrupeds that live on herbs or feeds, anfwer to birds that feed on the fame kind of aliment. The *fcreech-owl* among birds is the fame as the *cat* among four-footed animals. The *beaver* feems anfwerable to the *duck*. Quadrupeds may be divided into two principal claffes. The firft comprehends quadrupeds with a *folid* foot. The fecond comprizes quadrupeds whofe feet are furnifhed with *claws* or *toes*. Amongft quadrupeds of the firft clafs from the ftag to the hog, and thofe of the fecond, from the *lion* to the *moufe*, what a diverfity of models, fizes, and motions, do we obferve!

By what degrees does nature raife herfelf up to man?

How will fhe rectify this head that is always inclined towards the earth? How change thefe paws into flexible arms? What method will fhe make ufe of to transform thefe crooked feet into fupple and fkilful hands? Or how will fhe widen and extend this contracted ftomach? In what manner will fhe place the breafts, and give them a roundnefs fuitable to them?

The ape is this rough draught of man; this rude fketch; an imperfect reprefentation, which neverthelefs bears a refemblance to him, and is the laft creature that ferves to difplay the admirable progreffion of the works of God!

CHAP.

C H A P. IV.

Continuation of the gradual Progression of Beings.

1. THE relations which the plant bears to those beings that surround it, and from whence it derives its subsistence, are purely corporeal, or comprehended entirely within the sphere of the properties of bodies. The animal, which is more excellent, is allied to nature by other connections, and by such as are of a more exalted kind. Like the plant, it vegetates: like her, it receives that nourishment from without, which promotes the growth of it; and, like her, it multiplies. But to those different actions, are superadded *feeling*, or the *perception* of what passes within him. This sense of feeling is connected with several others, which are produced various ways; and they are all accompanied either with *pleasure* or *pain*.

Agreeable sensations inform the animal of the relations which certain bodies have to its preservation or welfare: *disagreeable* or painful sensations advertise him of qualities which are hurtful. He is then the center to which divers objects are directed: he draws near some, and keeps at a distance from others. The nerves, or that cluster of small fibres which extend themselves from the brain to all parts, like small cords, constitute the immediate organ of feeling.

2. Does ſpiritual perfection always anſwer to corporeal in animals? If this be true, how comes it to paſs, that the ſimple *oſtrich* appears inferior in point of underſtanding to the *lion piſmire*, which is placed ſo much beneath it in reſpect to ſtructure?

Let us not miſtake. The marks of underſtanding exhibited to us in ſome inſects are ſurprizing, inaſmuch as we do not expect to meet with them in thoſe animals we ſcarce think capable of feeling. Our imagination is warmed, and we aſcribe to thoſe inſects more genius than they really have.

On the contrary, we form high expectations from larger animals; ſo that we are very apt to degrade them, as ſoon as we perceive they fall beneath the idea we entertained of them. There are ſome however, whoſe mind does not diſplay itſelf by ſtriking marks, but by a great number of leſs ſenſible ones, which, being united, form a degree of underſtanding ſuperior to that of the moſt induſtrious inſect. Such, without doubt, would appear to be the caſe of the *oſtrich*, were ſhe better obſerved. We reproach her, with indifference towards her eggs. It is affirmed, that ſhe leaves the care of hatching them to the ſun. This reproach is turned into a commendation, with regard to the oſtriches of Senegal, ſince an exact obſerver has beſtowed on them the attention they require. In theſe ſcorching climates, the ſun ſufficiently heats in the day-time an oſtrich's eggs that are hid in the ſand. The warmth of the mother would be then unneceſſary, or even hurtful to them; ſhe would keep the ſun from them, whoſe rays are more active and efficacious

cacious. But the nights in Senegal are very cool: and the eggs would be in danger of growing cold. Then the mother never fails to procure them heat, by ſitting upon them during that time.

At the Cape of Good-Hope, where it is not ſo hot as at Senegal, the oſtrich ſits night and day, like other birds. The young ones peck in a few hours after they are hatched; but they are not able to walk till ſeveral days afterwards: the dam takes care to place near them ſuch food as is proper for them.

Laſtly, it is to be remarked, that there is a kind of ſociety among large animals. Their memory retains faithfully a certain number of ſigns and ſounds. Their ſoul is affected by a variety of perceptions: ſight and hearing alone furniſh an abundant ſource to them. Inſects afford us but very imperfect images of this. The *lion piſmire* is ignorant of every thing but the ſnare he has laid, and the prey he expects in conſequence of it. His eyes, which are motionleſs and unmeaning, differ widely from ours; nor is he affected by any ſound.

3. Thoſe are undoubtedly the moſt perfect animals, whoſe ſphere of underſtanding extends to the greateſt number of objects. Theſe are various in their operations, can ſhift about, and compaſs their ends by different ways.

The *polypus* only knows how to lengthen and contract his arms. The *ſpider* ſpreads a net with a geometrical regularity. The *falcon* and *dog* purfue their prey with fagacity. The *ape* prefumes to imitate *man*.

Has God created as many fpecies of fouls as of animals? Or is there only one fpecies of foul in animals, differently modified according to the diverfity of organization? This queftion is abfolutely impenetrable by us. All we can fay concerning it, is this: if GOD, who has always acted by the moft fimple means, has thought proper to vary the fpiritual perfection of animals merely by organization, his WISDOM has fo ordained it.

4. At the fummit of the fcale of our globe is placed *man*, the mafter-piece of the earthly creation.

Not to dwell on the excellent conftruction of his body, let us confider man as an intelligent being. Man is endued with reafon: he has ideas; he compares thefe ideas together; judges of their relations or oppofitions; and acts in confequence of this judgment. He alone, of all animals, enjoys the gift of *fpeech*; he cloaths his ideas with fuch figns as he thinks proper; and by this admirable prerogative he forms a connection between them, which renders his imagination and memory an ineftimable fund of knowledge. By this means man communicates his thoughts, and brings all his faculties to a ftate of perfection: by this he attains to all arts and fciences: and by means of this, all nature is fubject to him.

Sometimes, with a ftrong and harmonious voice, he celebrates, in a poem, the virtues of a hero. At others, by a ftroke of the pencil, he changes

changes a dull canvas into a charming perſpective. Here we ſee him, with the chiſſel and graver in his hand, animating the marble, and giving life to braſs. There, with the plummet and ſquare, erecting a magnificent palace. Now we behold him, by a microſcope of his own invention, diſcovering new worlds amidſt inviſible atoms, or penetrating the ſecret exerciſe and motion of a particular organ. At other times, by changing this microſcope into a teleſcope, he pierces into the heavens, and contemplates Saturn and his moons. Returning home, he preſcribes laws to the celeſtial bodies, deſcribes their paths, meaſures the earth, and weighs the ſun. Afterwards he dives into the nature of beings, examines their relations, and the admirable harmony reſulting from them, and by an attentive view of their various perfections, he ſees an immenſe chain formed, comprehending the whole.

In another ſtation, man is occupied in ſuch arts as contribute to the ſupply of his neceſſities, or conveniences. His reaſon condeſcends to every thing. The earth, cultivated by his care, teems every year with new productions. Hemp and flax diveſt themſelves of their bark to furniſh him with cloathing. The ſheep abandons for his uſe his rich fleece, and the ſilk-worm ſpins for him her precious woof. The yielding metal is moulded in his hands. The ſtone ſoftens in his fingers. The largeſt and ſtrongeſt trees fall at his feet, and receive from him a new being. All the animals are ſubject to his laws; even the fierceſt of them inſult not his crown with impunity. He makes ſome ſerve for food; others he harneſſes to his chariot; and others he condemns to till his lands.

Many of them he appoints to be his porters, hunters, guards, and muſicians. In ſhort, man plows his adventurous way acroſs the vaſt ocean, and by navigation unites the two extremities of the globe.

5. The EXCELLENCE of human reaſon ſhines likewiſe with a new luſtre, from the eſtabliſhment of *ſocieties*. In them, virtue, honour, fear, and intereſt, variouſly employed or combined, prove the ſource of peace, happineſs, and order. All the individuals, being mutually interwoven together, move in a regular and harmonious manner. Under the ſanction of the laws, the king, prince, and magiſtrate, by exerciſing a lawful authority, promote virtue, ſuppreſs vice, and ſpread around them the happieſt effects of their adminiſtration. In ſociety, as in a pure and fertile climate, talents of different kinds ſpring up and unfold themſelves. From that, the *mechanical* and *liberal* arts flouriſh. Laſtly, ſociety perfects friendſhip, that faithful companion of life, which adminiſters conſolation in our ſufferings, and gives a reliſh to our pleaſures.

6. The laſt mark of the greatneſs of man, and of his high exaltation above other animals, is the commerce he has with his CREATOR by religion.

Wrapped in the thickeſt darkneſs, the reſt of the animal creation are ignorant of the HAND that formed them. They enjoy an exiſtence, but cannot trace the AUTHOR of life. Man alone ſoars to GOD the PRINCIPLE, and proſtrate at the foot of the throne of the ALMIGHTY, adores with the profoundeſt veneration, and with the

the moſt lively gratitude, the INEFFABLE GOODNESS that created him.

In conſequence of thoſe eminent faculties wherewith man is enriched, GOD condeſcends to reveal himſelf to him, and to lead him as it were by the hand in the paths of happineſs. The various laws he has received from the SUPREME WISDOM, are ſo many lights placed at proper diſtances on his road, to guide him from time to eternity.

Enlightened by this CELESTIAL GUIDE, man advances in the glorious race that is ſet before him, and ſeizes the crown of life, and adorns with it his immortal brow.

7. Such is man in the higheſt degree of earthly perfection. But mankind have their gradations, as well as the other productions of our globe. There is a prodigious number of continued links between the moſt perfect man and the ape.

If you take a ſurvey of all nations of the earth; if you conſider the inhabitants of the ſame kingdom, province, city, or town; nay, do but examine with attention the members of the ſame family, and you will imagine you ſee as many ſpecies of men as you diſcern individuals.

To the Lapland dwarf, let the giant of Madagaſcar ſucceed. Let the flat-faced African, with his black complexion and woolly hair, give place to the European, whoſe regular features are ſet off by the whiteneſs of his complexion and beauty of his hair. To the filthineſs of a Hottentot, oppoſe the neatneſs of a Dutchman. From the cruel Anthropophagite paſs to the humane Frenchman.

Place

Place the ſtupid Huron oppoſite the profound Engliſhman. Aſcend from the Scotch peaſant to the great NEWTON. Deſcend from the harmony of the BOUGH to the ruſtic ſongs of the ſhepherd. Put in the ſame ſcale the lockſmith conſtructing a jack, and VAUCANSON forming his automatons. Reckon up the number of ſteps from the ſmith that cauſes the anvil to groan, to REAUMUR anatomizing fire.

Do theſe varieties ariſe from any real difference there is between human ſouls, independently in the organization of the body?

We ſhall not think ſo, if we pay a due attention to health and ſickneſs, to conſtitution and manner of living, to climate, and education.

You may perceive what a multitude of conſequences a mathematician derives from a very ſimple principle: place this ſame principle in the hands of a man of the lower claſs, it will remain barren, and not be productive of the ſmalleſt truth.

May not the number of juſt conſequences which different minds deduce from the ſame principle, ſerve as a foundation for conſtructing a pſychrometer upon; and may we not preſume that one time or other we ſhall be enabled to meaſure ſpirits as we now do bodies?

But the ſcale of the creation does not terminate at man. Another univerſe commences there, whoſe extent, perhaps, compared to that of this, is as the ſpace of the ſolar vortex to the capacity of a nut.

There ſhine the CELESTIAL HIERARCHIES, like glittering STARS.

There

There from all parts the *angels*, *archangels*, *ſeraphim*, *cherubim*, *thrones*, *virtues*, *principalities*, *dominions*, *powers*, caſt forth their radiant beams.

In the centre of theſe *auguſt ſpheres*, ſhines glorioufly the SUN OF RIGHTEOUSNESS, the EAST above, whence all the other *ſtars* borrow their light and ſplendor.

Ye planetary worlds! *celeſtial hierarchies!* you ſink into annihilation in the preſence of the LORD: your *exiſtence* is by HIM: HE IS THAT HE IS: HE *alone* poſſeſſes the plenitude of *being*, you enjoy but the reflection of it. Your perfections are ſtreams; the INFINITELY PERFECT BEING is an ocean, an abyſs, which the cherubim preſume not to look into.

If we enjoy a very ſenſible pleaſure on ſeeing collected, in one place, the principal productions of nature, how great muſt the ecſtaſy of celeſtial ſpirits be, when they ſurvey thoſe worlds which God has thick ſown in the vaſt expanſe, and when they contemplate the immenſity of his works!

O! the delightful employment thoſe *ſuperior intelligences* are exerciſed in, when they compare the different œconomies of theſe worlds, and weigh in the balance of reaſon each of theſe globes!

But all *celeſtial intelligences*, doubtleſs enjoy not theſe advantages in the ſame degree. There may be ſome perhaps to whom is granted the knowledge of one world only: others may know ſeveral: others a much greater number.

How immenſe muſt that MIND be, which beholds with a ſingle glance the ſum of all beings, and which by fathoming the *ſpirits* of all orbs, diſ-

cerns

cerns in an inſtant and without confuſion, the reſult of all the ideas that have, do now, and will hereafter occupy them!

Ye inhabitants of the earth, who have received reaſon ſufficient to convince you of the exiſtence of theſe worlds, will you for ever be denied entrance into them? Will the INFINITELY GOOD BEING, who ſhews them to you at a diſtance, always refuſe you admitance into them? No; ſince you are called to reſide e're long among *celeſtial hierarchies*, you will like them fly from planet to planet: you will eternally advance from perfection to perfection, and every inſtant of your duration will be diſtinguiſhed by the acquiſition of farther degrees of knowledge. Whatever has been with-held from your terreſtrial perfection, you will obtain under this œconomy of glory: *you will know even as you are known.*

Man is ſown corruptible, he will riſe incorruptible and glorious; theſe are the words of the *apoſtle* and philoſopher: the covering of the ſeed periſhes; the germ ſubſiſts, and aſſures man of immortality.

Man therefore is not in himſelf what he appears to be. What we diſcover of him here below is only the groſs foldage under which he crawls on the earth, and which he muſt ſhortly caſt off.

The *brain* is a ſmall organical machine, deſtined to receive the impreſſions made on the different parts of the body, and to tranſmit them to the ſoul. It is by means of this that the ſoul acts on various points of the body, and adheres to nature.

The extremities of all the nerves, radiate to the ſeat of the ſoul: it is in ſome meaſure the center

center of this admirable collection, the threads of which are so numerous, fine, delicate, and full of motion.

But the nerves are not stretched like the strings of an instrument of music. Animals that are intirely glutinous, are notwithstanding very sensible.

We then admit there is a fluid in the nerves, whose subtilty prevents our seeing it; and which serves both for the propagation of sensible impressions, and muscular motion.

The instantaneousness of this propagation, and some other phænomena, indicate that there is a certain analogy between the nervous fluid and fire or light.

We know that all bodies are impregnated by fire. It abounds in aliment. It is extracted from it by the brain, from whence it passes into the nerves.

The seat of the soul, the immediate organ of feeling and thought, can be no other than a composition of this vital fire. The brain which we see and feel, must therefore only be the case or covering of the ethereal machine, which constitutes the real seat of the soul.

It may indeed be the germ of that *spiritual* and *glorious* body, which REVELATION opposes to the *animal* and *vile*.

The *resurrection*, then, will only consist in a prodigiously rapid unfolding of this germ, which lies hid in the brain.

These senses are the foundation of those relations which the animal body bears to terrestrial bodies. The seat of the soul, or the little ethereal machine that constitutes it, has parts corresponding

ponding with the groffer fenfes, fince it receives motions from thence, and tranfmits them to the foul. Thefe parts, by the opening of the germ, will acquire a degree of perfection incompatible with the prefent ftate of man. But this germ may likewife contain within it new *fenfes*, which will difclofe themfelves at the fame inftant, and by multiplying in an almoft infinite degree the relations of man to the univerfe, will aggrandize his fphere, and render it equal to that of *fuperior intelligences*.

An organized body, formed of elements analogous to thofe of light, will, we may reafonably fuppofe, ftand in need of no repair. The *fpiritual* body will preferve itfelf by the mere energy of its mechanifm.

And if light or æther do not gravitate at all, man in a *glorified* ftate will be enabled to tranfport himfelf at pleafure into every point of fpace, and will fly from planet to planet, with the fwiftnefs of lightning.

The fenfes, as they will then be brought into fubjection to the foul, will no longer rule over her. Separated for ever *from flefh and blood*, there will remain in her none of thofe earthly affections which refulted from them. Tranfported into the regions of light, the human underftanding will prefent no ideas to the will but thofe of the higheft good. It will then have no other than lawful defires, and God will be their conftant and ultimate end. It will love him from gratitude; fear him from a principle of love; and will adore him as the SUPREMELY AMIABLE BEING, and as the *Eternal Source* of life, perfection, and happinefs.

CHAP.

CHAP. V.

Of the various relations of terrestrial Beings.

1. WE have seen, that all is relation in the universe, but we have only hitherto taken a distant view of this fruitful truth. We may now approach nearer to it, and bestow our attention on the most interesting particulars.

The union of souls to organized bodies, is the source of the most abundant and most wonderful harmony that exists in nature. A substance without extension, solidity, and form, is united to an extended, solid, and formed substance. A substance that thinks, and which has a principle of action in it, is united to a substance void of thought and purely passive. From this surprising connection there springs a reciprocal commerce between the two substances, a kind of action and re-action, which constitutes the life of *organized animated* beings. The nerves, being variously agitated by objects, communicate their motions to the brain, and to these impulses the perceptions in the soul correspond, which are totally distinct from the cause that occasions them.

The rays which proceed from an object strike my optic nerve, I have a *perception* that points out to me the presénce of the object. They affect this nerve in a violent manner; I have a *sensation*, which I express by the term of *pain*.

The diversity of *senses* by which the soul receives the impression of objects, produces a diversity in her perceptions and sensations. The sentiments

sentiments occasioned by the motion of the nerves of sight, differ absolutely from those that are produced by that of the nerves of hearing. The sense of feeling has no likeness to that of taste. These are different *modifications* of the soul, which correspond to different qualities of the objects.

But how can the nerves, which do not seem susceptible of a greater or less degree of bulk, length, composition, or tension, or of quicker or slower vibrations, occasion in the soul such a prodigious variety of perceptions as we experience? Is there such a relation between the soul and the machine to which it is united, as for certain perceptions to correspond continually with the nerves of a determinate size, structure, and tension? Are there nerves appropriated to different corpuscles, to the impression whereof various perceptions are attached? Are the pyramidal form of the *papillæ* of the taste and feeling, the winding cavities of the ear, the different refrangibilities of the rays of light, so many proofs of the truth of this? Be this as it may, we are sufficiently convinced that the same sensible fibre is not liable at one and the same time to a multitude of different impressions. But this fibre is not only destined to transmit to the soul the impression of the object; it must also preserve the remembrance of it; for a thousand instances prove that the memory is connected with the brain; how then can it be imagined that the same fibre should at once retain a multitude of different *determinations*? Nay, how can two such different substances as the soul and body act reciprocally on each other? At this question let us humbly cast our eyes downwards, and acknowledge this is one of the great mysteries of the creation, which we are not permitted

mitted to be acquainted with. The various attempts that have been made by the most profound philosophers, to explain it, are so many monuments raised to convince us both of the extent and weakness of the human mind.

2. The soul, being modified by impressions more or less strong, re-acts in her turn on the nervous system, maintains the motions there, and renders them more active or durable. From thence arise the *passions*, those secret inclinations, those restless appetites, which destroy the equilibrium of the soul, and impel her towards certain objects. These are admirable instruments set to work by the wise AUTHOR of nature; which, like favourable winds, cause the animated machines to float on the ocean of sensible objects!

The re-action of the soul on the nervous system, seems also to be the principal source of divers sensations we experience, several of which come under the denomination of *instinct* or *moral sense*.

Objects do not strike immediately on the soul. She only receives impressions by interposed *mediums*. The senses are the mediums. The action of objects, then is modified by them in a determinate relation to nature, or to the constitution of each medium. The aptness, either greater or less, wherewith sensible fibres yield to impressions from without, transmit them to the soul, and renew the remembrance of them there, together with the quality, and abundance of the humours, constitutes the temper. In animals, temper governs all. In man, reason regulates the temper: and the temper, when under due regulation, facilitates, in its turn, the exercise of reason.

The

The paſſions receive nouriſhment, grow, and become ſtrong like the fibres which are the ſeat of them. Learn then your temper, if it be vicious, you are to correct it; not to deſtroy it, for you would thereby deſtroy the machine itſelf; but ſkilfully to divert its courſe, and carefully to avoid every thing that may contribute to add new ſtrength to it, and ſwell the waters of ſuch a dangerous torrent.

3. The ſenſes, are not only intended to raiſe in the ſoul, perceptions of every kind; they likewiſe revive *memory* in her. A perception which is preſent to the memory does not eſſentially differ from that which the object excites. This produces perception by means of ſenſible fibres appropriated to it, and on which its action is diſplayed. The recollection of perception then depends on a motion which operates in theſe fibres, independently of the object, For whether the organ receives its motion from inteſtine cauſes, or from the object, the effect is the ſame with regard to the ſoul, and perception is inſtantly *preſent* to her.

Experience proves, that if any ſeries of perceptions whatever affects the brain for a certain time, it thereby contracts an habit of re-producing it in the ſame order. It is likewiſe certain that this habit appertains to the brain, and not to the ſoul. A burning fever, a ray of the ſun, or a violent commotion may deſtroy it, and ſuch cauſes influence only the machine.

All perceptions derive their origin from the ſenſes, and the ſenſes tranſmit to the ſeat of the ſoul, the impreſſions they receive from objects. But

But objects act on the organ by impulsion only. They impress then certain motions on the sensible fibres. So that a perception, or a certain series of perceptions, are connected with one or divers motions which operate successively on different fibres.

And since the reiteration of the same motions, on the same fibres, effects in them an *habitual* disposition to produce them afresh in a constant order, we may infer from thence, that the sensible fibres are so constructed as to produce in them changes or *determinations* more or less durable, which constitutes the precious ground-work of the memory and imagination.

But the sensible fibres are nourished like all the other parts of the body: they assimilate or incorporate with themselves alimentary matter: they grow, and whilst they receive nourishment, they continue to perform their proper functions. So that nutrition conduces to preserve to the fibres these determinations, and causes them to take root there; for as the fibres increase, they acquire a greater degree of consistence. We may hence discover the origin of *custom*, that powerful queen of the sensible and intelligent world. The memory, by preserving and recalling to the soul the *signs* of perceptions, by assuring her of the *identity* of the perceptions recalled, and of those which have already affected her, by connecting present perceptions with the antecedent ones, forms in the brain a fund of knowledge, which increases in richness every day.

The imagination, being infinitely superior to a Michael Angelo or a Raphael, delineates in the soul, a faithful image of objects; and from divers representations

representations which it composes, forms in the brain a cabinet of pictures, every part of which moves, and is combined with an inexpressible variety and swiftness.

The brain of man, then, may be considered as so many mirrors, wherein different portions of the universe are painted in miniature. Some of these mirrors exhibit but a small number of objects; while others represent almost the whole of nature. What is the relation between the mirror of the mole and that of a Newton! What images were there in the brain of a Homer, a Virgil, or a Milton! What mechanism must that have been which could execute such wonderful decorations! That mind, which could have read the brain of a Homer, would have there seen the Iliad represented by the various exercise of a million of fibres.

4. Of all the senses, the *sight* is that which furnishes the soul with the quickest, most extensive, and most varied perceptions. It is the fertile source of the richest treasures of imagination, and it is to that principally that the soul owes the ideas of *beauty*, of that *varied unity* which ravishes it.

But by what secret mechanism are my eyes made capable of communicating to me such lively, varied, and abundant perceptions? How do I discover with so much ease and quickness every object that surrounds me.

Three *humours* of different density, each lodged in a transparent capsule, divide the inside of the globe of the eye into three parts. On the bottom is is ſpread a kind of cloth, or very fine membrane, which is only the expanſion of a nerve, whoſe extremity terminates immediately at the brain. A black ſkin lines the whole inſide of the globe. At the fore part of it is a round orifice, which contracts or dilates itſelf according as the light is more or leſs ſtrong. Six muſcles, which are placed on the outſide of the globe, move different ways, and the rapidity of thoſe motions is exceſſive,

What need is there of theſe humours, this cloth this tapeſtry, this aperture which contracts and dilates itſelf? The light comes to us from the ſun in a right line: but theſe rays become *crooked*, when the denſity of the *mediums* through which they paſs increaſes or diminiſhes. This is called the *refraction* of light.

To the property of *refracting* light, joins that of *reflecting* from the body it enlightens. There iſſue then luminous ſtreaks from all points of the objects, which bear the image of theſe points.

The humours of the eye are the lens of the camera obſcura; the cloth or *retina* are the paſteboard. The black ſkin which hangs within the ball performs the office of a ſhutter that excludes the light; it extinguiſhes the rays whoſe reflection would render the image leſs diſtinct; the *ball*, by contracting or dilating itſelf in proportion to the ſtrength of the light, moderates the action of the rays on the retina: the nerve placed behind this, communicates to the brain the various concuſſions it receives. to which divers perceptions correſpond.

5. Such are the admirable relations which WISDOM has placed between our eyes and the

light:

light: those which it has established between light and the surfaces of different bodies, whence *colours* proceed, are not less worthy our attention.

A ray which falls on a glass prism, divides into seven principal rays, each of which bears its *proper* colour. The oblong image which this refraction produces, affords seven coloured stripes, distributed in a regular order. The first, reckoning from the upper part of the image, is *red*; the second, *orange*; the third, *yellow*; the fourth, *green*; the fifth, *blue*; the sixth, *indigo*; the seventh, *violet*. These stripes do not glare: but the eye passes from one to the other by gradations or shades.

The rays which bear the highest colours, as the red, orange, and yellow, are those that *refract* or curve the least in the prism. They are also such as *reflect* the first, on inclining the instrument.

From thence it follows, that each ray has its fixt degree of *refrangibility*. Make one of these rays pass through several prisms at the same time; it will afford you no new colours: but it will constantly retain its primitive colour, which is an invincible proof of its *immutability*. Present a lens to seven rays divided by the prism, you will re-unite them into a single ray, which will afford you a round image of a shining *white*. Take only five or six of these rays with the lens; you will have but a dusky white. Only re-unite two rays; you will make a colour, that will partake of both. A stream of light then is a cluster of seven rays, whose re-union forms *white*, and the division of which produces seven principal and *immoveable colours!*

What is now the source of that infinite diversity of colours, which embellishes every part of our abode?

abode ? The particles which compose the surface of bodies, are so many little *prisms* variously inclined, which break the light, and reflect different colours. Gold divided into very thin plates appears blue, when opposed to broad day light. The greater or less thickness of the plates contributes then to the diversity of colours. Whence proceeds that beautiful azure which tinges the canopy of heaven ? The ground of the heavens is black ; this ground viewed through the body of air which surrounds us, must appear blue to us. Whence proceeds this smiling verdure which adorns our fields ? The lamellæ of the surface of plants are disposed in such a manner, that they remit only green rays, whilst they afford a free passage to others. If green pleases our sight, it is because it holds precisely a medium between the seven principal colours. But who can remain insensible of the care which NATURE has taken to depart from uniformity in this case, by multiplying in so great a degree the shades of green ? You admire this magnificent rainbow, which delineates at large to you the colours of the prism : the beauty and vivacity of its shades ravish you : you suspect that nature must have been at a vast expence to compose this rich girdle. Some drops of water, on which the light breaks and reflects in different angles, are the sole cause of it.

You are struck with the splendid gilding of some insects : the rich scales of fishes attract your notice : NATURE, who is always magnificent in design, and frugal in execution, produces these brilliant decorations at a small charge : she only applies a brown thin skin on a whitish substance : this skin performs the office of varnish to our gilded skins ; it modifies the rays which issue from the ſubſtance it covers. The gloſſy green of the leaves of plants is owing to the ſame art. They owe their luſtre and ſhades to a fine, ſmooth, tranſparent, gloſſy, and whitiſh membrane which cloaths a ſubſtance that is always of a *rough* green, and of a ſtronger or fainter dye. It is this green modified by this membrane, which conſtitutes the colour peculiar to leaves of every ſpecies.

It is apparently the ſame with regard to the enamelling of flowers, and perhaps likewiſe to the colouring of fruits. This is a new branch of optics, which were it dived into as it deſerves, might be attended with ſome intereſting conſequences.

The direct light of the ſun, or that of the day only, tinges the leaves, as it colours that of fruits. Leaves, whilſt they are incloſed within the bud, are whitiſh or yellowiſh. They preſerve this colour, if obliged to grow in a tube of blue paper, where the air and heat may have free acceſs. The plant then *ſtars*, as the gardeners term it, ſending forth an exceſſively long and ſlender ſtalk, and the leaves unfold themſelves but very imperfectly. The light is in a continual and very rapid motion: it acts perpetually on the ſurface of bodies, which it penetrates more or leſs. By its ſmall reiterated ſtrokes on leaves, it modifies the ſurface of them by little and little, and inſenſibly diſpoſes it to reflect the green colour.

Colours then in objects are only a certain diſpoſition of parts totally diſtinct from the perceptions which they cauſe in the ſoul. It is the ſame with reſpect to all our perceptions and ſenſations. The ſenſes, by preſenting to us bodies under different appearances, ſhew us their various qualities;

lities; and to these qualities different ideas in the soul correspond. We conclude from hence, that the same objects do not affect all sensible beings in an equal manner. It is even doubtful whether two individuals of the same species have precisely the same perceptions in presence of the same objects.

Were we to contemplate the world by the organs of all those sensible beings which inhabit it, we should perhaps see as many worlds as we should employ glasses. What difference would there appear in the mulberry-tree, examined through the organs of a silk-worm, from our conception of it! What diversity between the *stamina* viewed through the eyes of bees, and those which the botanist observe! How extensive would be the knowledge of that being, who could be acquainted with all these different impressions!

6. *Fire*, which is dispersed through all nature, offers to us an infinity of properties: let us confine ourselves to give an account of the most interesting. Fire being subtle, elastic, and continually agitated, penetrates all bodies. It warms, dilates, burns, melts, calcines, vitrifies, volatilizes, and dissipates them, according to the nature of their composition or principles. This subtle element becomes visible only by borrowing a body. It secretly unites itself to an inflammable and unknown substance, and provided with this body, unites itself to other bodies, and enters into their composition. It is by means of the same union that it becomes sensible in *electrical* experiments. sometimes in the form of luminous tufts, sometimes in that of crowns, flashes, sparks, and that

it fulminates, bursts, strikes, pierces, burns, inflames.

By a gentle agitation fire enlivens all organized bodies, and conducts them by degrees to their perfect growth. It foments the branch in the bud, the plant in the grain, the embryo in the egg. It gives suitable preparations to our food. It subdues metals to our use, over the formation of which it presides. By that we are enabled to give matter, all those forms which our necessities or conveniencies require. To that we are indebted, in a particular manner, for that transparent matter, which being stretched out into thin leaves, or fashioned like tubes, vases, globes, lenses, furnishes us with various instruments, and enriches us with new eyes, which help us to discover the smallest objects, and bring nigh to us the most remote.

From the action of fire on earth, sulphur, oils, and salts, the various species of fermentations and mixtures result, which are the objects of the researches of the chymist, and the soul of the three kingdoms. Being concentered by lenses or mirrors of every kind, it acquires a strength greatly superior to that of the hottest of our actual fires, and in an instant reduces green wood to ashes, calcines stones, melts and vitrifies metals.

Being excited, collected, condensed, modified, extracted, directed, and applied by electrical machines, it becomes the fruitful source of a thousand phænomena, which art diversifies every day. Sometimes, when extracted from a globe of glass, it runs with an inconceivable rapidity along an iron wire, and causes light bodies, placed at a league distance from the globe, to feel the impression of it. Applied by the same means to paralytic limbs, it it restores life and motion to them. Being present in all parts of the atmosphere, it collects itself in stormy clouds, from whence it is again extracted by art; and a *Le Monnier*, equal to the fabulous Jupiter, holds the thunderbolt, and disposes of it at his pleasure. It is likewise fire that communicates to air and water, when reduced into vapours, that prodigious force which renders them capable of shaking the earth, and breaking the hardest bodies.

Lastly, it is fire, that by penetrating fluids, preserves to them their fluidity. As it is exact itself, in putting itself in equilibrio, it passes from those bodies where it is most abundant to those where it is least so, and carrying with it the most volatile particles, it deposits them on the surface of the latter, where they appear in the form of vapours, exhalations or mists.

7. The air, by its fluidity, thinness, weight, and spring, is next to fire the most powerful agent in nature. It is one of the great principles of the vegetation of plants, and of the circulation of liquors in all organized bodies. It is the receptacle of the particles which exhale from different matters; and had we eyes sufficiently piercing, we should see in it the abridgement of all the bodies that exist on the surface of our globe. From vapours and exhalations which it carries in its bosom, and disperses into all parts, are produced *aqueous* and *fiery* meteors, which are so useful, but sometimes dreadful.

The air does not only receive bodies: it even enters into their composition. When divested of its elasticity, it unites itself to the particles which compose them, and augments their bulk. But being more unalterable than gold, it resumes its former nature, when these bodies change or are dissolved. Being disturbed in its equilibrium, it swells the sails of our ships, and conveys to our countries those rich fleets that cause plenty. Becoming impetuous, it causes tempests and hurricanes; but even this impetuosity is not without its use; the air by this means divests itself of noxious vapours, and the waters being strongly agitated, are preserved from a fatal corruption.

Lastly, the air is the vehicle of sounds and odours, and under these new relations it is essentially allied to two of our senses. The partial vibration which commotion excites in a *sonorous* body, communicates itself to all the globules of air that immediately incompass this body. These globules cause the like vibrations in those contiguous to them: and this exercise continues in the same manner to greater distances than we are able to determine. A fine and elastic membrane, spread at the bottom of the ear like the parchment of a drum, receives these concussions, and conveys them to three small bones placed end to end, that communicate them in their turn to certain bony and winding cavities, lined on their inside with nervous filaments, which join to the brain by a common trunk. The greater or less degree of swiftness of these vibrations produces seven principal tones, analogous to the primitive colours. From the combined relation of various tones, harmony proceeds.

The infinitely small particles that are continually detached from the surface of odoriferous bodies, float in the air, which transports them every where, and applies them to the nervous membranes

branes that are distributed in the inside of the nose. The concussions which these corpuscles occasion therein, pass afterwards to the brain by the lengthening of the nervous filaments.

8. All climates have their productions: all parts of the earth their inhabitants. From the frozen regions of the bear, to the burning sands of the torrid zone, all is animated. From the top of the mountains to the bottom of the valleys, every thing vegetates and respires. The waters and the air are peopled with an infinite number of inhabitants. Plants and animals are themselves little worlds that nourish a multitude of people, as different from each other in their figure and inclinations as the great people are which are scattered over the surface of our globe. What am I saying? The smallest atom, the least drop of liquor are inhabited. Wonderful harmony, which by thus suiting different productions to different places, leaves none absolutely desert!

9. A reciprocal commerce connects all terrestrial beings. Inorganized beings answer to organized as to their center. The latter are designed for each other. Plants are allied to plants. Animals to animals. Animals and plants are linked together by their mutual services. Behold how closely this young ivy entwines itself round this majestical oak. It draws its sustenance from it, and its life depends on that of its benefactor. Ye great ones of the earth, ye represent this oak. Refuse not your support to the indigent; suffer them to approach you, and to obtain from you sufficient to relieve their necessities.

Consider this caterpillar thick-set with hair; the birds dare not touch it: notwithstanding which, it serves them for food: by what means? a fly pierces the living caterpillar. She lays her eggs in his body. The caterpillar remains alive. The eggs hatch. The young ones grow at the expence of the caterpillar, and are afterwards changed into flies, which serve for sustenance to the birds.

There are continual wars betwixt animals; but things are so wisely combined, that the destruction of some of them occasions the preservation of others, and the fecundity of the species is always proportionable to the dangers that threaten individuals.

10. All is metamorphosis in the physical world. Forms are continually changing. The quantity of matter alone is invariable. The same substance passes successively into the three kingdoms. The same composition becomes by turns a mineral, plant, insect, reptile, fish, bird, quadruped, man.

The organized machines are the principal agents of these transformations. They change or dissolve all matters that enter within them, and that are exposed to the action of their secret springs. They convert some into their own substance; others they evacuate under divers forms, which render these matters proper for entering into the composition of different bodies. Thus animals that multiply prodigiously, as some species of insects, have perhaps for their principal end that of metamorphosing a considerable quantity of matter, for the use of different compounds. By that means the vilest matters give birth to the richest productions; and from the bosom of pu-trefaction

trefaction there issues the finest flower, or the most exquisite fruit?

The AUTHOR of NATURE has left nothing useless. What is consumed of the dust of the stamina in the generation of plants, is very trifling, if compared with the quantity each flower furnishes. WISDOM itself then has created the industrious bee, that makes use of the superfluous part of this dust with such art and œconomy, as could not be too much admired in the most skilful geometricians.

The earth enriches us every day with new gifts, whereby she would at length be exhausted, if what she supplies us with were not restored to her. By a law, which we do not pay a proper attention to, all organized bodies become uncompounded and insensibly change in the earth. Whilst they suffer this kind of dissolution, their volatile parts pass into the air, which transports them every where. So that animals are buried in the atmosphere as well as in the earth and water; we may even doubt whether that portion which the air receives be not the most considerable in bulk. All these particles dispersed here and there, soon enter into new organical wholes, destined to the same revolutions as the former. And this circulation, which has subsisted from the beginning of the world, will continue as long as it endures.

CHAP. VI.

Of VEGETABLE ŒCONOMY.

1. THERE is no ſource of phyſical relations that is more abundant than the œconomy of organized bodies. Let us caſt an eye on what it offers to us of the moſt intereſting nature. Our plan does not lead us to dive into a ſubject that exhauſts the ſagacity of a philoſopher.

Organical ŒCONOMY, taken in the moſt extenſive ſenſe, is that ſyſtem of laws according to which the vital functions operate in organized bodies.

Conſidered in a leſs view, organical œconomy preſents us with two claſſes of objects. The firſt comprehends the *ſtructure*, *arrangement*, and *exerciſe* of the different parts of organized bodies. The ſecond comprizes the various effects that reſult from organization.

2. The plant *vegetates*, is nouriſhed, grows, and multiplies. The ſaline, unctuous, and ſubtle ſlime, which the water ſeparates from the coarſe earth, and keeps in a diſſolved ſtate, is the principal nutriment of plants. The different ſpecies of manure only contribute to the fertilizing of land, in proportion as they introduce into it a great quantity of a ſpongy powder or active ſalt. If a natural philoſopher ſucceeds in raiſing plants, and

and causing them to bear flowers and fruits in other matters than earth, for instance, in the powder of rotten wood, deal, saw-dust, very fine sand, moss, cotton, paper, sponges: the reason is, because several of these matters either change insensibly in the ground, or actually contain earthy parts, or the water which moistens them is itself charged with these particles, which the organs extract, prepare, and assimilate.

After having been admitted into the body of the root by the extremity of the *fibres*, the nutritious juice rises into the *ligneous* fibres from the trunk or stalk, and passes into the *utricles* that adhere to them. It is there prepared and digested. It afterwards enters into the *proper vessels*, under the form of a coloured fluid, more or less thick, which we may conjecture to be with respect to the plant, what the chyle or blood is to the animal. Being filtred by finer or more winding pipes, it is at last conveyed to all the parts, whereto it unites itself, and increases their bulk.

The extreme fineness of the canals for the *sap*, which renders them in some measure *capillary* pipes, the action of the air on the elastic sheaths of the air-vents, and the impression of these last on the ligneous fibres they contain, or by which they are comprized, the heat that rarefies the sap, and above all that which, by acting on the surface of the leaves, draws thither the superfluous nutritious juice, and occasions the evaporation of it, seem to be the principal causes of the ascent of this fluid in plants. The quantity of nutriment, which a plant derives from the earth is in proportion to the number and size of its leaves; the smaller or fewer in number the leaves are, the less

leſs it draws. The nutrition of vegetables is likewiſe effected immediately by their leaves. They do not only ſerve for raiſing the ſap, preparing it, and diſcharging its ſuperfluity; they are moreover a kind of roots that pump from the air the juices they tranſmit to the neighbouring parts.

The dew, which riſes from the ground, is the principal foundation of this aereal nouriſhment. The leaves preſent to it their inferior ſurface; which is always furniſhed with an infinite number of ſmall pipes that are always ready to abſorb it. And that the leaves may receive no prejudice in the exerciſe of this function, they are diſpoſed with ſuch art on the ſtalk and branches, that thoſe that immediately precede do not cover ſuch as ſucceed them. Sometimes they are placed *alternately* on two oppoſite and parallel lines. Sometimes they are diſtributed by pairs, that croſs each other at right angles. Sometimes they are ranged on the angles of *polygons* circumſcribed on the branches, and ſo diſpoſed that the angles of the inferior polygon correſpond with the ſides of the ſuperior. At other times they aſcend the whole length of the ſtalk and branches on one or more parallel *ſpiral* lines.

Ye ſceptics, can you inform me why plants are diſpoſed with ſo much art? You will perhaps deny that plants imbibe the dew by their inferior ſurface! But what would you ſay, were one to inform you, that among leaves exactly reſembling each other, and taken from the ſame tree, ſuch as have been ſteeped by their inferior ſurfaces in veſſels of water, have continued green for the ſpace of whole weeks, and even months; whilſt thoſe that have been placed, by way of experi-

ment

ment, with their upper ſurface in the water, periſhed in a few days?

Herbs that are always immerſed in the thickeſt beds of dew, and that grow much faſter than trees, have their leaves formed in ſuch a manner, that they pump in the moiſture nearly alike by both ſurfaces, ſometimes more copiouſly by the upper one.

Obſerve laſtly, that the inferior ſurface of the leaves of trees is commonly leſs ſmooth and gloſſy and of a paler colour than the oppoſite ſurface. This remarkable difference between the two ſides of the leaf, ſufficiently indicates that they have different uſes.

3. By a mechaniſm which is very ſimple, the root forces itſelf into the earth; the branches ſhoot out on each ſide: the leaves expoſe their ſuperior ſurface to the open air, and their inferior ſurface to the earth, or the inner part of the plant. Sow a ſeed the contrary way; you will obſerve the radicle and little ſtalk to bend backwards; the former in order to reach the earth, and the latter to gain the air. Keep a young ſtalk inclined; its extremity will grow upwards. Bend the branches of all ſorts of plants; cauſe the inferior ſurface of their leaves to turn towards the ſky; you will ſoon perceive that all theſe leaves will turn back again, and reſume their former poſition: which motion will be executed with a quickneſs proportionate to the heat of the ſun, or ſuppleneſs of the leaves. Sow different kinds of ſeeds in a cloſet or cellar: carry thither ſome ſmall twigs having their extremity ſteeped in veſſels full of water. The leaves of the

the young plants and thoſe of the twigs, will incline their upper ſurface to the windows or air-holes.

Conſider the leaves of divers ſpecies of herbaceous plants; of the *mallow* for inſtance; you will remark that they follow the courſe of the ſun. In the morning you will ſee them preſent their upper ſurface to the eaſt; towards the middle of the day this ſurface will face the ſouth: in the evening it will be turned to the weſt. At night or in rainy weather theſe leaves will be horizontal, their inferior ſurface looking towards the earth.

Trace likewiſe the leaves of the *acacia*; as ſoon as they are heated by the ſun, you will obſerve all their foilages draw together by their upper ſurface. They will then form a kind of gutter turned towards the ſun. In the night, or in moiſt weather you will ſee the foilage turned the contrary way, and contract themſelves by their inferior ſurface. They will then form a gutter that will face the earth.

4. Do not ſeek for *circulation* in plants; as they are more ſimple than animals, every thing in them is performed with leſs apparatus.

In the day-time the action of the heat on the leaves, draws to them in abundance the nutritious juice. The ſmall excretory veſſels, that appear in the forms of globules, pyramids, filaments, ſeparate the more aqueous or groſs parts of the juice that riſes from the root. The air contained in the tracheæ of the ſtalk and branches, by dilating itſelf more and more, preſſes the ligneous fibres, and by that means accelerates the courſe of of the ſap, at the ſame time that it cauſes it to penetrate into the neighbouring parts.

When night approaches, the inferior ſurface of the leaves begins to perform one of its principal functions. The little mouths it is provided with open themſelves, and receive the vapours that float in the atmoſphere. The air of the tracheæ is confined within them; their diameter is leſſened: the ligneous fibres being leſs preſſed, enlarge themſelves, and admit the juices conveyed to them from the leaves. Theſe juices join themſelves to the reſidue of that which had ariſen in the day-time, and the whole maſs tends towards the roots.

This ſeems to be exactly the mechaniſm to which the motion of the ſap may be reduced. You now ſee more clearly the deſign of the direction of the leaves, and of their admirable reverting. The inferior ſurface being intended for imbibing the dew, ſhould face the earth, from whence this vapour riſes gradually at ſun ſet. But when I ſay that the principal office of this ſurface, at leaſt in trees and ſhrubs, is to receive the dew, I would not infer that the oppoſite ſurface is incapable of it: that may perhaps abſorb vapours that are more rare.

Experiments that are well made ſeem to prove, that the inferior ſurface of the leaves of trees ſerves likewiſe for inſenſible perſpiration. Thoſe leaves in which this ſurface was endued with a matter impenetrable by water, drew in and tranſpired much leſs, in an equal time and with the ſame management, than leaves of the ſame ſize and likeneſs, whoſe inferior ſurface had not been endued with ſuch a varniſh. It ſeems to have reſulted from the ſame experiments, that there is but

but little perſpiration by the upper ſurface. We may thence infer that one of its principal functions is, to ſerve for a ſhelter or defence to the lower ſurface: and that no doubt is the uſe of the gloſſy varniſh obſervable on the ſuperior ſurface. All which agrees with the almoſt ſpontaneous motions and directions of the leaves, and with their ſymmetrical diſtribution round the ſtalks and branches.

5. The plant being incloſed in miniature within the fruit or ſeed, is there encompaſſed with a quantity of flour, which after being diluted by the water that has penetrated the incloſures, ferments and furniſhes the *germ* with its firſt nouriſhment. Being moiſtened by the delicate milk, in proportion to its weakneſs, it grows from day to day. In a ſhort time its coverings become incommodious; it endeavours to diveſt itſelf of them, and puſhes forth a little root, which proceeds to ſeek for more nouriſhing juices in the earth. The little ſtalk appears in its turn. As it is deſtined to live in the air, it pierces the earth, and darts perpendicularly into the aereal fluid. Sometimes it carries along with it the remains of the teguments that had enwrapped it in the germ ſtate; at other times it is accompanied by two leaves, which are very different from thoſe of a mature age; theſe are the *ſeminal* leaves, whoſe principal uſe is probably to refine the ſap.

Though it is diveſted of its ſwadling-clothes, if we may ſo term them, the young plant is not at full liberty. It is not in a condition to be expoſed ſo early to the impreſſions of the air and ſun. All the parts remain for a ſhort time folded together, nearly as they were in the ſeed. But the root,

by

by extending and ramifying itſelf more and more, conveys to the veſſels a conſiderable quantity of ſap, which ſoon opens all the organs.

At its firſt appearance the plant is almoſt gelatinous. It aſſumes by little and little a greater degree of conſiſtence by the incorporation of the juices which flow to it from all parts. That part of the ſtalk next the root increaſes in bulk, extends itſelf, and hardens firſt of all. As the hardening augments, the extenſion diminiſhes. At length it entirely ceaſes in this part, and continues in that which immediately follows. Such is the nature of the progreſſion obſerved in the whole plant.

Wood, whoſe hardneſs is ſometimes equal to that of ſtone, is formed of a ſucceſſion of concentric layers, that are detached every year from the inſide of the rind, and harden as they advance in age.

6. Vegetables multiply by *ſeed*, *ſhoots*, and *ſlips*. The *piſtil* and *ſtamina* are to plants what the organs of generation are to animals. The former incloſes the ſeed; the fine powder of the latter fœcundates it. Both ſexes are frequently united in the ſame ſubject: and thoſe ſpecies are real hermaphrodites. Others bear the piſtil on one branch, and the ſtamina on another. A third ſort are like the greater part of animals, diſtinct males and females. The former are furniſhed with a piſtil, and the latter with ſtamina. This is all we know with regard to the generation of plants.

When the ſtamina are cut off, the ſeed remains unfruitful. The ſame thing happens when any one that has piſtils has not in its neighbourhood another

another provided with ſtamina. The piſtil is always ſo diſpoſed as to be able to receive the duſt of the ſtamina. Its top is perforated with holes proportioned to the diameter of the grains of this duſt, and its inſide is divided into ſeveral canals, whoſe diameter diminiſhes the nearer they approach to the bottom. At the baſe of the piſtil the ſeed is depoſited. Every grain of the duſt of the ſtamina is a box, wherein floats, in a kind of very thin vapour, an infinite multitude of other very minute grains. This box opens itſelf to the moiſture, and diſcharges a ſmall miſt of globules or grains.

The ſhrinking of the trunks indicates that the *containing* globules do not reach to the bottom of the piſtil: but the *contained* globules or grains are ſet at liberty by the action of the moiſture which the trunk imbibes, which, by opening the little box that incloſes them, permits them by this means to penetrate to the *ovary*.

7. Vegetables multiply by *ſhoots*. They puſh forth from the circumference of their root ſeveral ſuccours, which become plants themſelves, and propagate their ſpecies in like manner. The branches and young ſhoots may likewiſe be conſidered as ingrafted on the principal plant making one body with it. The germs which are diſperſed within the plant, infold themſelves there without any ſenſible fecundation, and reach to the ſurface of the bark. They appear there in the form of a ſmall oblong and rounded body, compoſed of ſeveral parts, ranged in a very regular manner, and ſhaped like tubes, ſhells, &c. This little body is the *bud*, which like the ſeed, incloſes the young

young plant under ſeveral coverings, all the parts of which are compleated with abundance of art.

The little ſtalk ſhoots forth a ſimilar bud at its upper extremity. This bud opens, and produces a ſecond ſtalk, grafted on the firſt, which it lengthens. This new ſtalk produces a third; the third a fourth, and ſo on ſucceſſively. When the tree has attained its full growth, it is compoſed of a ſeries of ſmall trees, placed end to end. It is the ſame with reſpect to branches and boughs, all having one and the ſame life, and forming only one organical whole.

Bulbous plants, inſtead of young ſhoots, ſend forth ſuckers. The bulb, which is formed of ſeveral membranes, or coats placed on each other, contains, in like manner as the ſeed and bud, a plant in miniature. The ſucker is a ſmall bulb that ſhoots out on the ſides of the principal one, and which is deſigned to ſucceed or replace it. Sometimes this replacing is performed with ſuch quickneſs and circumſtances as are very ſurprizing. Whilſt the principal bulb is waſting, the ſucker thickens and ſpreads itſelf, and in a ſhort time becomes the principal bulb.

We may compare this bulb to a ſpecies of earth, that exhauſts itſelf in order to furniſh ſuitable juices to the young plant, It may alſo be looked upon as a *placenta*, that filtres and prepares the nutritious juice. The leaves of ſome herbaceous plants form ſpherical maſſes that are pretty compact, and ſeem to perform the office of a bulb. The head of a cabbage ſpends and waſtes itſelf in order to contribute to the unfolding of the minute ſtalk it contains. Place one of theſe heads on a

veſſel

veſſel full of water, and it will exhibit to you the ſame phænomena as the bulb of a flower.

8. The branches that bend down from certain trees to the earth, take root there, and become themſelves young trees. Human induſtry carries this kind of multiplication to a much greater extent. By means thereof, a ſingle branch or root, divided into ſeveral parts, becomes ſo many individual plants. What do I ſay? It can even cauſe a tree to be produced from the ſmalleſt ſhred of a leaf. Such is the multiplication from *ſlips*.

The organs eſſential to life being diſperſed throughout the whole body of the ſubject, the ſlip that is detached from it, and planted in the earth, is of itſelf capable of forming new productions; it has every thing neceſſary for the unfolding of the radicles and buds. Thus a ſingle leaf takes root, and vegetates by its own ſtrength.

There is another kind of multiplication that is very remarkable, which conſiſts in planting one or more ſlips, not in the earth, but in the trunk or branches of a living tree. This is *grafting*; the firſt idea of which may perhaps have been owing to the accidental union of two branches or two fruits.

The next cauſe of the union of the graft with its ſubject, is in the intercourſe of the ſap-veſſels with each other; and this intercourſe depends ultimately on the relation of their parts, and particularly on that of their conſiſtence, and the liquors contained in them. By the aſſiſtance of a graft the gardener cauſes the wild ſtock to produce the fineſt fruits, he gives youth to trees, and gathers plumbs from the almond tree, and pears from

from the ash. Filtration, and the preparation of the juices of the subject by the vessels of the graft, occasion these productions. The *roll* which is always formed at the *insertion*, and is composed by the interweaving of a prodigious number of fibres, is one of the principal instruments of these preparations. The more or less perfect analogy of the juices proper to the *subject* with those that are peculiar to the *graft*, favours in a greater or less degree the unfolding of the latter. The nearer or more distant relation between the time in which the sap in the subject continues, and that in which the graft has been accustomed so to do, contributes likewise more or less to the success of the operation.

9. The body of the plant is in a continual state of motion. It always tends to produce, either the bark, a bud, or a root. Make an incision in a tree; the wound will cicatrise. A greenish roll will in a short time be seen at the top of the wound, afterwards on the sides, and at length towards the bottom. This roll is a new rind, which is about to cover the wood again, without uniting to it. Observe what passes with respect to this; you will perceive in it certain distinct and glutinous nipples, and small reddish spots dispersed here and there, which you will find to be a growing bark. A matter that is partly transparent, whitish and mucilaginous will seem to raise up this bark. All these glutinous substances will thicken, increase in length, and become stronger, and in a little time what was at first of a glewy nature will be herbaceous, cortical and ligneous. The cicatrice will at length entirely close itself, and restore the communication between all the vessels.

The

The *wood* does not only differ from the *bark* by its denſity, but it has likewiſe organs that are not to be met with in the latter. It ſeems to be peculiarly poſſeſſed of air-veſſels. When a new rind ſeems to convert itſelf into wood, this converſion is only in appearance. Nature does not create more air-veſſels than are ſuited to one intire plant. But a multitude of fibres that are deſtined to become wood, pre-exiſt under the new rind, and unfold themſelves with it and by it, as we ſee the butterfly unfold itſelf in and by the caterpillar. Whilſt wood is nothing more than a mucilaginous drop, it is not on that account the leſs wood, than when, being transformed into a pillar, it is made to ſupport the enormous weight of an edifice.

In the union of the *graft* with its *ſubject*, we likewiſe perceive a glutinous ſubſtance to ſpring from each of them, which ſpreads, ramifies, and is formed into a ball in both, becoming by degrees herbaceous, cortical, ligneous, and compoſes above the *inſertion* a roll which entirely covers it. So that the whole body of the plant is furniſhed with ſmall fibres on the inſide, which only wait for favourable circumſtances to diſplay themſelves. Theſe circumſtances are a wound, an inciſion, or a ſimple ligature. Theſe fibres are the elements of cortical or ligneous beds, which by ſpreading themſelves on all ſides, furniſh the neceſſary repairs. The wound, inciſion, and ligature, occaſioning the nutritious juices to flow towards theſe inviſible fibres, expand them, and render them perceptible to us.

What

What these fibres perform in the regeneration of the bark or wood, the *germs* effect in the reproduction of a branch or young shoot. The fibres of the bark or wood do not unite themselves into bunches, in order to compose a *bud* or branch in miniature. This branch is already completely formed in its germ: it there possesses the elements of all the beds, whether cortical or ligneous, which it will hereafter exhibit under different proportions.

CHAP. VII.

Of Animal Œconomy.

1. THE *nerves*, which extend themſelves into all parts from the brain, are diſtinguiſhed into ſeveral principal *diviſions*, that are more or leſs numerous, or more or leſs extended. Each diviſion reaches to the part for which it is deſtined, and whoſe ſtructure correſponds with the functions appointed for it to exerciſe.

Feeling, ſight, hearing, taſte, and ſmell, are five kinds of ſenſes, which contain under them an almoſt infinite number of ſpecies. The ſhaking which the mediate or immediate impreſſion of objects produces on the nerves, gives birth to thoſe different kinds of ſenſations, which may all be reduced to *feeling*, of which they are properly only modifications. The organs of the ſenſes are the inſtruments of theſe modifications. The number, extent, and delicacy of the *ſenſes*, conſtitute the degree of *animal perfection*.

The nerves, which ſeem to reſemble the ſtrings of a muſical inſtrument, are not ſtretched like them. Some animals are endued with an exquiſite ſenſation, that are themſelves little otherwiſe than a thick jelly: how then can we admit of elaſtic ſtrings in this jelly? While the fœtus is altogether gelatinous, it regulates at that time its members. With what amazing ſwiftneſs then muſt the impreſſions of objects communicate themſelves

ſelves to the ſoul! and with what wonderful celerity muſt the members obey the will! Thus we are led to ſuppoſe in the nerves a very ſubtle and elaſtic fluid, whoſe motions, being analogous to thoſe of light or electrical fluid, produce all the phænomena of ſight. The *animal ſpirits* are this fluid, which the brain extracts and prepares, and continually conveys into the nerves, and by the nerves into all parts, which it nouriſhes, moves, and animates.

2. An animal had in vain received ſenſes, by means of which it can diſtinguiſh between what is uſeful or hurtful, if it were not enabled to give itſelf any motion for the attaining the one, and avoiding the other. It is therefore furniſhed with organs that procure to it this faculty. Theſe organs are the *muſcles*, which by the dilatation and contraction, and by the lengthening and ſhortening of the fibres that compoſe them, communicate to all parts the motions, which are ſuited to the wants of the animal.

It is evident from experiments, that the nerves contribute to the exerciſe of the muſcles. The ſpirits which they diſperſe therein, inſinuate themſelves into all the veſicles, dilate them, and by that means put the organ into action.

One property of the muſcular fibre (whoſe effects are diverſified a thouſand ways, the cauſe of which is concealed from us) is that, by virtue whereof it contracts itſelf on the touch of any body either ſolid or liquid. This is called *irritability*. By means of this, different parts of the animal continue to move, after they have been ſeparated from their intire body; and the heart when detached from the breaſt, performs a number of pulsations, which cease as soon as the blood in the cavity is evacuated.

3. From that part which gives admittance to the food to that from whence issue the remains of the grosser aliment, there is one continued canal, which is formed, differently in different parts of its extent. There are three principal parts distinguished in it, the *æsophagus*, the *stomach*, and the *intestines*. All these are formed of various membranes laid on each other, and which are themselves composed of fibres differently interwoven. The muscles, wherewith one or several of these membranes are furnished, impress divers motions on the organ, the principal of which, called the *peristaltic* motion, bruises the aliment, and forces it from place to place.

The *æsophagus* receives the grosser nourishment, and transmits it to the *stomach*, that prepares it: it afterwards passes into the *intestines*, where it undergoes new preparations. From thence it enters into some very small vessels, that convey it to those of *circulation*, where it assumes the name of *blood*.

Whilst the most delicate part of the aliment is subject to all these preparations, the grosser part is evacuated by different ways. Sometimes the animal discharges it as a *sediment*; sometimes, being transformed into a subtle liquor, it is carried to the surface of the skin by an infinite number of very fine vessels, whose exterior apertures are sometimes so small, that a grain of sand is capable of covering several thousands of them.

Other vessels, which, like them, communicate with the surface of the skin, pump in the vapours that float in the air, and convey them into the blood.

4. *Circulation*

4. *Circulation* is that perpetual motion by which the blood is conveyed from a point internally to the extremities, and flows back again from the extremities to the same point. The point from whence the blood springs, is called the heart. It has two motions, one of contraction, or *systole*, by means of which it forces out the blood contained in its cavity; the other of dilatation, or *diastole*, by which it receives the blood again.

Two kinds of vessels join to the heart: the *arteries*, which convey the blood to the extremities; and the *veins*, which carry it back from the extremities to the heart.

The arteries have, like the heart, their systole and diastole, and divide and subdivide themselves, as do the veins, into an infinite number of branches which diminish in diameter in proportion to their distance from their origin. The perpetual motion of circulation prevents the corruption and extravasation of the nutritious fluid, rectifies it more and more, and disposes it insensibly to renew the nature of the animal.

5. *Respiration* comprehends two alternate motions; one of *inspiration*, which gives admittance to the air within; the other, of *expiration*, which expels it, filled with the vapours of the animal.

The *lungs* are the principal instrument of respiration. They are principally formed of a collection of cartilaginous and elastic vessels, which after being divided and subdivided into a prodigious number of branches, meet in different parts, and terminate at one or more common trunks, called *tracheæ*, or air-vessels, whose aperture is on the outside of the body. The ramifications of the air-vessels are connected with the vessels of

 circulation,

circulation, and accompany them in their paſſage through the lungs.

6. The blood is that rich fund from whence nature derives that diverſity of materials ſhe employs with ſo much art in the conſtruction of her wonderful edifice. This, as it goes from the heart, meets, here and there on its paſſage, with certain organical, and as it were knotted maſſes, in which it is deprived of part of its principles.

We cannot yet penetrate the true mechaniſm of *ſecretions:* we can only faintly perceive, that they may operate by a gradual diminution of the veſſels which proportions them to the ſmallneſs of the particles that are to be ſeparated. They may likewiſe bear ſome affinity to the configuration of theſe particles, and favour the extraction of them by means of the ſlackening which their folds and various circumvolutions occaſion to the circulation. Thus it is, that by cauſing the aliment to paſs through an infinite number of ſtrainers, nature is enabled to *aſſimilate* it to the animal, and incorporate it into his fleſh. This is then neither chyle nor blood; it is a much more refined liquor, and known by the vague name of lymph.

We cannot ſufficiently admire the prodigious apparatus of veſſels which perform the ſecretions of different kinds. The kidneys, the liver, the pancreas, &c. are labyrinths in which the moſt conſummate anatomiſt is bewildered. We can only diſcover an inconceivable maſs of white tubes, of an extreme minuteneſs, folded together in thouſands of different ways, which do not admit of any injection, though adhering to the blood-veſſels

veſſels, and being placed end to end by imagination, would have formed a chain of ſeveral leagues in length. This is all that art has diſcovered in the ſecretary organs. But what a number of intereſting particulars do theſe minute hollow cylinders contain, which have eſcaped our notice and inſtruments! What varieties ſhould we not diſcover in their ſtructure, functions, and exercife, were we permitted to deſcend to the bottom of this abyſs, which conceals from us one of the greateſt myſteries of nature! All the animal liquors are more or leſs mixed, and theſe ſmall tubes no doubt ſufficiently diverſify themſelves to ſeparate the various molecules that muſt neceſſarily enter into the compoſition of every liquor. What then muſt be the ſtructure and fineneſs of thoſe that filtre this ſo ſubtile fluid, compared to æther or light, whoſe operations are diverſified almoſt to infinity!

7. If we knew how a ſingle fibre *grows*, we could tell how the animal *grows*; for his whole body is only an aſſemblage of fibres differently formed and combined. Growth always operates by nutrition. This incorporates into the fibre molecules of an heterogeneous nature, which extend in every part. The fibre incorporates into itſelf the heterogeneous molecules according to its own nature. A fibre is not itſelf compoſed of other fibres: theſe of ſtill other fibres: of which there would be no end. But the fibre is formed of molecules or *elements*, whoſe nature, proportions, and arrangement reſpectively determine the *ſpecies* of the fibre, and adapt it to ſuch or ſuch a function.. Thus the elements of the fibre ultimately effect aſſimulation, which by uniting with the nutritious molecules,

that have an *affinity* with them, give them at the same time an arrangement like that which they have in the fibre. The extenſion of the fibre ſuppoſes that its elements may ſeparate more or leſs from each other; but this ſeparation hath its bounds, and theſe bounds are thoſe of the growth. In proportion as the fibre grows, it acquires more ſolidity; for the number of incorporated molecules increaſes every day, ſince it only grows by the ſucceſſive incorporation of molecules of a foreign nature. The more the ſolidity augments, the more the ſuppleneſs diminiſhes. There are more molecules, more coherence, and more attraction under the ſame foldage. The fibre then tends to a ſtate of hardneſs, and the laſt term of its hardening is the laſt term of its growth. When therefore the fibre has acquired its full growth, it is a little organized whole, compoſed of its *elementary* molecules and of all ſuch as nutrition has incorporated with them during the time of their growth. If then we could ſeparate from the fibre all thoſe molecules which it has aſſimulated, we ſhould reſtore it to its *primitive* ſtate. This may be applied to all organized bodies. They are, if we chuſe to term them ſo, net-work. A ſecret force impels the aliment into the meſhes. It increaſes them in bulk, and ſupplies them by little and little. It likewiſe inſinuates itſelf into the elements of the ſolid maſs itſelf. The net-work ſtretches, thickens, and at length becomes hard.

8. We may eaſily comprehend, that all the parts of an animal have ſuch ſtrict and indiſſoluble connexions between them, that they muſt neceſſarily have always co-exiſted together. The arteries imply veins; both of theſe imply nerves; the

the latter the brain; this the heart; and all of them suppose a multitude of other organs.

In the germ of a chick there is at first perceived a *vital point*, whose constant motion attracts the attention of the observer. The alternate and quick contractions and dilatations of the living point, sufficiently indicate that it is the heart. But this heart seems to be without any covering, and to be placed on the outside of the body. Instead of appearing in the form of a minute pyramidial mass, it bears the resemblance of a semicircle. The other viscera appear successively, and range themselves after each other, round the living speck. We cannot as yet discover any general folding; all is transparent or nearly so; and we only perceive by little and little those teguments which are appointed to cover all the parts.

In its first beginnings the animal is almost intirely fluid. It assumes by degrees the consistence of a jelly. All the parts have at that time situations, forms, and proportions that differ greatly from those they will afterwards acquire. Their minuteness, softness, and transparency, serve to strengthen the illusion. We persuade ourselves that a bowel is naked, because the transparency of its coverings prevents our seeing them.

Would you have a short and easy demonstration of this? When the lungs of the chick are first perceivable, their size is but the thousandth part of an inch. It would have been visible at the fourth part of these dimensions, were it not endued with the most perfect transparency. The liver is much greater at its first appearance; its transparency alone renders it invisible. It is the same with respect to the kidnies; whilst they do not even appear to exist, they separate the urine.

The heart forces the blood into the arteries sooner than we could imagine, and it can only be perceived by the growth of the embryo, which is never more accelerated than at the very beginning.

Many other facts concur with these to establish the pre-existence of *organical wholes*. We are now sensible that many insects multiply, like plants by *slips*. We cut them into pieces, and each piece regenerates, and becomes a perfect animal. Earth worms are ranked in the number of those insects that are re-produced from their disjoined parts; and being very large, the phænomena of their regeneration is very perceptible. The piece that is cut off never acquires any growth; it always remains as the section left it; only it falls away in a greater or lesser degree. But after some time there appears a very small whitish pimple at its extremity, which encreases by degrees in bulk and length. There are soon discovered rings, which are at first very small and very close. They spread themselves insensibly every way. New lungs, a new heart, a new stomach disclose themselves, and with them a number of other organs. This piece, which is newly produced, is extremely slender, and altogether disproportioned to the part on which it grew. We may imagine that we see a worm growing, that is grafted at the end of this stump, endeavouring to lengthen it. This little vermiform appendage unfolds itself slowly. At length it equals in thickness the piece from which it was cut, and exceeds it in length. It can no longer be distinguished from it but by its colour, which is somewhat fainter.

Here then is a new organical whole, which grows from an antient one, and constitutes the

same

ſame body; there is an *animal* ſlip that grows, and expands itſelf on the ſtump of an animal, as a vegetable ſlip does on the trunk of a tree. Remark that the fleſh of the piece cut off does not in the leaſt contribute to the formation of the part regenerated; the ſtump only nouriſhes the bud; it being the ſoil in which the latter vegetates. The part then that is re-produced paſſes through all the degrees of growth, by which the intire animal itſelf had before paſſed. It is a real animal, which pre-exiſted in a very minute form in the great animal that ſerved it for a matrix.

Vegetable productions exhibit to us the ſame conſequences. If a tree be topped, that does not lengthen the trunk of it; but it ſends forth a multitude of buds, in each of which a little tree is comprized; for the bud or branch that ſprings from it is a tree that is grafted on the trunk that nouriſhes it.

Every ſeed in like manner comprizes a plant in miniature. On a very ſlight inſpection, we may very eaſily diſcover the ſtalk, leaves, and root of this little plant. But the curious riſe much higher, and diſtinguiſh in a bulbous root or growing bud thoſe flowers that do not blow till the enſuing year.

When the evolution commences in an organized whole, its form differs ſo prodigiouſly from that which it will afterwards aſſume, that we ſhould be apt to miſtake it, were we not to accompany it in all its progreſs. Obſerve how the parts of a plant are folded together, entwined, and concentred in the ſeed or bud. Is this that majeſtic tree which will e're long overſhadow a large ſpace of ground? This the flower that will ſo gracefully diſplay itſelf? This the fruit that will assume such a regular figure? You can now only perceive an unformed mass of knotted filaments; yet this little chaos may already contain in it a world, where all is organized and symmetrical.

You have seen frogs in their first state. They appear at that time to consist only of a large head and a long tail. Such is the chick when it begins to expand itself. A very slender tail stretched in a strait line is joined to a large head; and the tail contains all the rudiments of the composition; nay, is the very composition itself; and the transparent fluid in which it floats, constitutes the whole of those soft parts with which it is afterwards covered.

The same revolutions therefore, which occasion the heart of the chick to be transformed from its semicircular shape to that of a pyramid, bring the chick itself to a state of perfection. If we were permitted to penetrate to the foundation of the mechanism whereby these successive changes are effected, what a degree of certainty would our knowledge of animal œconomy acquire? We should contemplate in an egg the mysteries of the two kingdoms, And how greatly would our admiration of that ADORABLE WISDOM be increased, which by the simplest means ever attains the most noble end?

9. Thus the more we ascend to the origin of organized beings, the more we are persuaded of their having pre-existed before their first appearance; not such as they first appear to us, but more disguised; and were it possible for us to trace them still higher, we should undoubtedly find them still more disguised, and should be at a loss to conceive how they could afterwards acquire that form under which they present themselves to our view.

We

We can then form no idea of the *primitive ſtate* of organized beings; that ſtate which I conceive to be given them by the hand of HIM who has ordained all things from the beginning.

The forms of vegetables and animals, which are ſo elegantly varied, are, in the ſyſtem of this admirable pre-ordination, only the laſt reſults of that multitude of ſucceſſive revolutions, they have been liable to, and which perhaps commenced at their firſt creation. How great would be our aſtoniſhment, could we penetrate into theſe depths and pry into the abyſs! We ſhould there diſcover a world very different from ours, whoſe ſtrange decorations would infinitely embarraſs us. The ſtate, in which we conceive all organized bodies to have been at firſt, is the *germ* ſtate; and the germ contains in miniature all the parts of the future animal or vegetable. It does not then acquire organs which it had not before; but thoſe organs which did not hitherto appear, begin now to be viſible. We do not know the utmoſt limits of the diviſion of matter; but we ſee that it has been divided in a prodigious degree. From the elephant to the mite, from the globe of the ſun to a globule of light, what an inconceivable multitude of intermediate degrees are there! This animalcule enjoys the light; it penetrates into its eye; it there traces the image of objects; how extremely minute muſt this image be! And how much more minute muſt that of a globule of light be, when ſeveral thouſands, and perhaps millions enter at the ſame time into this eye! But great and ſmall are nothing in themſelves, and have no reality but in our imagination. It is poſſible, that all the germs of the ſame were originally joined or linked into each other, and that they are only unfolded from generation to generation

generation, according to that progreſſion which geometry endeavours to aſſign them.

10. A *barren* egg has a *yolk* as well as a fruitful egg. And a ray of light has lately ſprung, which has greatly brightened the ſhades in which the myſtery of generation is yet involved.

Beſtow your whole attention on this; you will then diſcover an important truth. A membrane cloaths the inſide of the yolk of an egg: and this membrane, which is only a continuation of that which cloaths the *ſlender* inteſtine of the chick, is common to the ſtomach, pharynx, mouth, ſkin, and epidermis. Another membrane enfolds the yolk externally, and this membrane is only a continuation of that which covers the inteſtine; it unites with the meſentery and peritoneum. The arteries and veins that gently move in the egg, derive their origin from the meſenteric arteries and veins of the embryo. The blood which circulates in the yolk receives the principal of its motion from the heart.

The yolk then is eſſentially a dependance of the inteſtines of the embryo, and together with that compoſes one and the ſame organized whole. So that at its primary period, it is in ſome meaſure an animal with two bodies; the head, trunk, and extremities, compoſe one of theſe bodies; the inteſtines and yolk the other. At the end of the incubation the ſecond body connects with the firſt, and both together form only one.

But ſince the yolk exiſts in eggs that have not been fecundated, it neceſſarily follows that the germ exiſted before fecundation. This conſequence is ſelf-evident: you have lately ſeen that the yolk is an eſſential part of the chick: you have obſerved the ſtrict communication between them

them. The chick then has never exifted without it. The membranes and veffels of the former are only a continuation of the membranes and veffels of the latter. And what a number of other thing are there which are common to both, and which prove that they have never exifted feparately! The chick then was entire in the egg before fecundation. It does not therefore owe its origin to the liquor furnifhed by the cock, but was fketched in miniature in the egg previous to it. Confequently the germ belongs folely to the female. Such is the grand conclufion which immediately flows from facts.

11. The yolk has its liquors, which are conveyed to it by the arteries belonging to it. They circulate, and without veins there is no circulation. But the arteries and veins of the yolk take their origin from the mefenteric arteries and veins of the fœtus: the heart of this latter therefore is the principle of that circulation which is performed in the yolk. At the time of fecundation the fœtus does not weigh the hundredth part of a grain. The yolk at that time weighs a dram. It has veffels proportioned to its fize, Now if the germ exifted intire before fecundation, that which we ftile generation is not the fame thing with it; but is only the beginning of an *evolution*, which will by degrees bring to open day fuch parts as were before hid in impenetrable darknefs.

But the germ cannot be unfolded in an egg which has not been fecundated, and incubation would only accelerate its corruption. What does it then want to enable it to continue to grow? It has all the organs neceffary for evolution. It has even already attained to a certain degree of growth,

growth, for eggs grow in young pullets; their ovaries contain them of all ſizes. The germ grows there likewiſe. Why cannot it enfold itſelf more than it does? What ſecret force retains it within the limits of inviſibility?

Growth depends on the impulſion of the heart. A greater degree of growth, depends on a greater impulſion. This degree of impulſion, conſequently is wanting in the heart of the germ that has not been fecundated.

This demonſtrates a certain reſiſtance in the parts of the germ. As it grows this reſiſtance augments in proportion. Some reſiſt more than others; the bony parts, or ſuch as will hereafter become ſo, more than the membranous, or thoſe that muſt always remain ſo.

The heart of the germ then hath need of a determinate ſtrength to ſurmount this reſiſtance. Its ſtrength is in its *irritability*, or in the power it has of contracting itſelf on the touch of ſome liquid. Wherefore to augment the irritability of the heart, is to augment its impulſive force.

Fecundation, without doubt, increaſes this force, and that can alone increaſe it; ſince it is only by the intervention of it that the germ paſſes over the narrow limits that retained it in its firſt ſtate.

12. The fecundating liquor then is a true *ſtimulus*, which being conveyed to the heart of the germ, excites it in a powerful manner, and communicates to it a new activity. Herein conſiſts what we call *conception*. Motion being once impreſſed on the little moving body, is there preſerved ſolely by the energy of its admirable mechaniſm.

But

But it is not ſufficient that the heart ſhould acquire a force ſufficient to ſurmount the reſiſtance of *ſolids*; it is likewiſe neceſſary that the fluid which it conveys to them, and which ſhould *nouriſh* them, be proportionable to the exceeding fineneſs of the veſſels. Such a blood as ours would not circulate in them. The blood of the embryo is at firſt a whitiſh liquor; it grows yellow by degrees, and afterwards red. The more the impulſion of the heart dilates the veſſels, the more groſs heterogeneous, and colouring particles they admit.

The prolific liquor then is not a mere *ſtimulus*; but is likewiſe a nutritious fluid appropriated to the extreme delicacy of the germ. It has already diſcharged the functions of a nutritious fluid in the fecundating individual; has cauſed its comb, ſpurs, &c. to grow, and given ſtrength to all his parts.

Being conveyed by the arteries to all the parts, it unites itſelf to the nature of each. From thence proceeds *growth*, which we do not pay a ſufficient attention to.

It is not long before the chick loſes the firſt form. Wings, thighs, legs, and feet, ſpring out from its long tail. Every thing is formed and diſpoſed on a new model. The little animal, which before was ſtretched out in a ſtrait line, becomes more and more curved. It is ſucceſſively cloathed with muſcles, tendons, fleſh, and feathers, and in eighteen or twenty days is a perfect chick.

13. If the chick pre-exiſted in the hen, it is probable the horſe pre-exiſted in the mare. This would be more than probable, if it could be demonſtrated

monstrated that the young of viviparous animals are enclosed in *eggs*; and that all the difference between viviparous and *oviparous* may be reduced to this, that the former are hatched in the belly of their mother, and the latter after their issuing from it.

On the two sides of *viviparous* females there is a body resembling a bunch of grapes, whose berries are bladders full of a limpid liquor. These are the *ovaries*. They communicate with the *matrix* by two canals which they call *tubes*. The prolific liquor penetrates into the matrix, and passes through the tubes into the ovarie. Thus fecundation is performed. Foetus's have more than once been found in the ovaries itself. Nay more, there has been found in a vesicle of the ovary a complete fœtus sketched in miniature.

The vesicles of the ovary are real *eggs*, which after fecundation descend through the tubes into the matrix, and are there in some measure brooded on. In a short time they send forth small roots, which convey the nourishment to the embryo. The suppleness of their membranes admits of their extending, and making way for the growth of the little animal. It is true, the *growing* of eggs is not familiar to us; but the history of insects furnishes us with many examples of it. It even exhibits to us insects that are at one time viviparous, and another oviparous. The young were in that case at first lodged in eggs; sometimes the mother lays her eggs; and at another brings forth living young ones, which were hatched from these eggs whilst they were yet in the matrix.

It is therefore the same with respect to the vesicles of the ovary, as the eggs of the hen; a

germ

germ pre-exiſts in them, but its tranſparency conceals it from us; fecundation renders it viſible.

14. But if an aſs cover a mare, there will be produced from this commerce an animal that will not properly be a horſe, but a *mule*. Nevertheleſs a horſe was delineated in miniature in the egg of a mare: how then was it transformed into a *mule?* Whence did it acquire theſe long ears and ſlender tail ſo different from thoſe of the horſe? Diſſection encreaſes the difficulty; that informs us that this kind of transformation does not only affect the exterior part of the animal, but the interior likewiſe. The voice of the mule is very like that of the aſs, and does not at all reſemble the neighing of a horſe. The organ of the aſs's voice is an inſtrument that is very much compounded. A drum of a ſingular ſtructure, lodged within the larynx, is the principal part of this inſtrument. This drum does not exiſt in the horſe, but is found in the mule.

The liquor furniſhed by the male conſequently penetrate the germ, ſince it there produces ſuch great changes. But theſe relations of the prolific liquor to the male that furniſhes it, muſt neceſſarily depend on the organs that prepare it.

There are then in theſe organs veſſels that ſeparate the molecules relative to different parts of the great whole. Theſe molecules are carried to the correſponding parts of the germ, ſince theſe parts are modified by the action of the prolific liquor. Therefore it incorporates itſelf with the germ, and is the firſt aliment of it, as I ſaid above.

The

The organs of generation in the afs have then a relation to his ears and larynx; for they prepare a liquor which modifies the ears and larynx of the little horfe inclofed in the egg. The prolific liquor creates nothing, but it may change what already exifts. It does not engender the chick, which exifted before fecundation.

Growth depends on nutrition; the latter, on incorporation. At the fame time that a part grows, it requires folidity. An excefs of growth in a part, then, fuppofes a fuper-abundance of nutritious juices, or fuch as are more active. The exceffive growth which the ears of the horfe acquire by the influence of the liquor of the afs, indicates that this liquor contains more molecules appropriated to the unfolding of the ears than that of the horfe or that the molecules of the firft are more active than thofe of the fecond.

The extreme foftnefs, I fhould rather fay fluidity of the germ, renders every part of it extremely modifiable. Thofe changes which you cannot conceive in an adult, depend here on the flighteft caufes.

But if the fecundating liquor modifies the germ, this latter in its turn, modifies the action of that liquor. By virtue of its organization, it tends to preferve its primitive ftate, refifts more or lefs every new arrangement, and never gives way without always retaining fomething of its primitive form.

15. Every organical production, which has more or lefs parts than the fpecies require, or conftructed otherwife, is a *monfter*. The *mule*, which doth not engender, is therefore a *monfter*.

The

The object of inquiry in a celebrated dispute was, whether certain monsters were such *originally* or *by accident?*

It is evident, that the *mule* is not a monster *from its origin*. Monsters do not exhibit so much constancy and uniformity. Does an egg of which the mule is formed offer itself in the ovary of the mare just at the instant in which the ass fecundates it?

Two branches, fruits or leaves, graft themselves accidentally, and afterwards compose but one and the same whole. Art performs other more extraordinary engraftings, in all of which there is nothing originally monstrous.

That which happens between two fruits that ingraft themselves, or are ingrafted by force, may happen in the matrix between two eggs, or in an egg between two germs. Two fœtus's that are united only by the spine, perfectly resemble two fruits that are grafted *by contact*. An egg sometimes contains two yolks; consequently it then contains two germs. How easy a matter is it for them to ingraft themselves together as they unfold? We have seen a chicken with four feet. which undoubtedly proceeded from a like union. The germs, which are first fluid, and for a considerable time gelatinous, are very penetrable. If they come in contact, they will mix together in part. Similar organs, which at least half penetrate each other, will subsist in the other moiety. We see clearly this reciprocal penetration in a human fœtus having two heads on a single body. This monster was evidently formed of two moieties of the fœtus connected together.

If their gelatinous state renders germs very penetrable, it favours with much greater reason their union

union by grafting, or that of some parts to each other, either of the same germ or two or more germs. The *graft* is united to its *subject* only by gelatinous or at least by herbaceous fibres. Such fibres are proper for forming new productions, and for connecting and intermingling together. Two polypus's unite together much more easily than two rinds; they are abundantly softer.

16. *Accidental* grafts may give birth to monsters which we should term inexplicable, by this principle. But you have not forgot, that all organical parts have forms and situations in the germ which differ prodigiously from those they will have in the unfolded fœtus. Recal to mind the *chick* in its first form, its heart in that of a semicircle and you will comprehend that those conjunctions which appear impossible to you in the fœtus, may be easily affected in the germ.

The *analogy* of parts likewise favours their union. This analogy results from that of the elements. Two membranes are more disposed to unite than a membrane and a bone; and similar parts of the same organ, than parts of different organs.

Lastly, evolution is not uniform in all parts of the germ: they grow unequally, and this inequality of growth may influence the effects of contact, pressure, adhesion, &c. Thus a monster that is produced with superfluous members, may derive them from a germ that has perished, and of which only these members remained. We plainly see how many causes may destroy such or such a part, and produce a monster *by defect*.

But

But all monſters *by exceſs* might not owe their origin to the union of two germs. Certain parts may grow exceſſively by the concurrence of particular circumſtances, and augment the number of ſimilar parts in the ſame individual. A ſubject with twenty-ſix ribs is really a monſter by exceſs. It has been proved, that ſupernumary ribs are entirely owing to the unnatural developement of a bony appendage of the tranſverſe apopyſis of one of the vertebræ. The cauſes which operate in the like unfoldings, act nearly as the liquor of the aſs on the ears and larynx of the horſe.

As ſupernumerary ribs unfold themſelves, ſo two or three ribs unite themſelves into a ſingle one, and theſe kind of caſes are not rare either in the vegetable or animal kingdom. Such parts as almoſt touch each other, are very apt to unite: two drops of jelly, and of the ſame jelly, unite very eaſily.

17. The principles I have laid down concerning the generation of animals, are likewiſe applicable to that of plants. What the prolific liquor is to the former, the *duſt of the ſtamina* is to the latter. There is a wonderful analogy betwixt theſe two claſſes of organized bodies. The ſeed, which ſo nearly reſembles the egg, does therefore in all probability contain a germ, which exiſted in an inviſible manner before fecundation, and which makes it ſenſible to us. It appears firſt of all like a greeniſh or yellowiſh ſpeck. It has been thought that a grain of the ſtamina duſt has been parceived in this ſpeck. The germs have on this account been placed in this duſt, and introduced themſelves into the ſeeds, which were deſtined to receive and nouriſh them. But can we diſcover the germ in the egg before fecunda-tion

tion? Notwithſtanding which it pre-exiſts there. It is highly probable that it likewiſe pre-exiſts in the ſeed, and that its minuteneſs together with the tranſparency of its parts, conceals it from our ſight Will a philoſopher argue, that becauſe a thing is inviſible to us, it does not therefore exiſt?

18. An exact obſerver has taken a good method to clear up the myſtery of the generation of plants. He conſidered what has reſulted from the *fecundation* of divers ſpecies, by the duſt of different ſpecies. He has ſeen *mules* that have been well deſcribed proceed from it. Theſe mules, when combined with other ſpecies, have produced new ones. The reſemblances have always been in a direct proportion to the *duſt*. The changes and alterations have always been ſenſible. The female has had ſome ſuperiority. The priviledge of *fecundity* has adhered more exactly to what came from her, than to that which proceeded from the male. Do not theſe curious obſervations themſelves indicate, that in vegetables, as well as in animals, the germ originally belongs to the female?

CHAP.

CHAP. VIII.

Of animal Oeconomy, confidered in Infects.

1. THE fketch I have lately drawn of animal œconomy, affords a flight idea of what conftitutes the effence of life in moft animals. We fhall now treat of the principal varieties which the organization of different fpecies prefent us with. Infects, hitherto little known, exhibit fome fingularities in this refpect, to which we fhall confine ourfelves by way of preference, in order to avoid fuch details as might carry us to too great a length.

We have already feen in fome meafure the different parts contained in the compofition of thefe little machines: we will now contemplate their exercife and various effects.

2. The mechanifm of *refpiration* is very obfcure in infects. We only know that in them it differs greatly from that in thofe animals which are moft known to us. But we judge with greater certainty concerning this difference by the comparifon of the organs, than by that of their exercife. When a drop of greafy liquor is applied to one or feveral ftigmata of an infect, the correfponding parts become paralytic. The interception of the air in one part is followed by that of liquors or fpirits. When we ftop up all the ftigmata, the infect dies immediately. If we afterwards open them, we fhall perceive the infide to revive. The air which

 then

then penetrates the open orifices of the tracheæ, evidently produces this kind of resurrection.

The tracheæ or air-vessels are divided and subdivided in a prodigious degree. May they not resemble so many sieves, which by separations suitably contrived, are capable of furnishing to each part an air of a more or less subtle nature, as occasion requires. There are commonly reckoned to be nine stigmata on each side of the body: but sometimes they are more in number, at others fewer. The same insect has some that are of greater or less importance to it, or whose functions are more or less necessary. In several species, the principal stigmata are placed behind: in others at the head. Instead of stigmata, they are pretty frequently observed to have little tubes of different lengths.

3. The *circulation* of the blood is performed in insects with great regularity. We trace it by our sight, in some species of long and transparent worms. We may see the heart, or principal artery, contract and dilate itself successively in every part of its extent. It seems to be composed of a great number of little hearts, placed end to end, that transmit the blood to each other.

We are yet ignorant in what manner the blood is conveyed into the grand artery. Its principal ramifications, and the canals analogous to veins, are equally unknown. We are only certain, that in many species, for the most part of the creeping sort, the principle of circulation is towards the hinder part, whereas in others it is towards the head. It is very probable that the grand artery shoots forth, from both sides of it, several branches that are invisible by reason of their extreme fine-

ness

neſs or tranſparency, and that diſtribute the blood to every part. Other branches are without doubt connected with them, and conduct the reſidue of the blood to the principal trunk of veins, which is imagined to be perceived on the oppoſite ſide of the heart. The blood of inſects is a ſubtle liquor transparent, commonly without colour, and though it be not in the leaſt *inflammable*, reſiſts, in ſome ſpecies, a degree of cold ſuperior to that of our ſevereſt winters.

4. The *organs of generation*, in moſt inſects, are placed at the extremity of the belly. That which characteriſes the *male*, conſiſts principally of one or two ſpecies of *fleſhy horns* which are turned different ways, and are generally drawn within the body, but emitted from thence at the pleaſure of the inſect. The hind part of divers males is alſo furniſhed with *hooks*, by means of which they faſten on that of the females. In the interior part are lodged different veſſels, which are connected with the principal organ of generation, and ſeparate the *fecundating* liquor from the maſs of blood. At the end of the aperture formed in the *female*, there is joined a kind of canal, which, in many inſects, ſends forth ſeveral branches, called *tubes* or *ovaries*. Theſe are ſpecies of very fine inteſtines, in which the eggs are ranged in a row, almoſt like the beads of a chaplet.

The eggs neareſt the aperture are the largeſt, or in a more *advanced ſtate*. They gradually diminiſh according to their diſtance. At length they become altogether inviſible.

In the common paſſage where the ovaries terminate, there is inſerted, in ſome ſpecies, a very ſhort canal, which communicates with an oblong cavity, that is conſidered as analogous to the *matrix*. In this cavity the liquor of the male is depoſited.

Amongſt *viviparous* animals the œconomy of the tubes changes. Sometimes the young are ranged in bunches. At others they form a kind of cord twiſted ſpirally, whoſe length, width, and thickneſs exactly correſpond in number to the length and thickneſs of the young that compoſes it. The young of ſome viviparous inſects, before they are brought forth, tear the membrane or ovary that incloſes them: they are, to uſe the expreſſion on this account ſubject to a two-fold birth.

The eggs of inſects are of two kinds: ſome are *membranous*, like thoſe of tortoiſes and reptiles: others are *cruſtaceous*, as are thoſe of birds. But whereas in large animals the ſpecies comprized under theſe genera differ only from each other by a ſlender variety, amongſt inſects theſe varieties are ſo great, that one animal does not differ more from another, than one of their eggs does from another. Some of them are round, elliptical, lenticular, cylindrical, pyramidal, flat. Some are quite ſmooth, others grooved or channelled. In ſhort, what is more extraordinary, there are ſome eggs that grow after they are laid. We eaſily judge that they are entirely membranous. The ſuppleneſs of their membranes admits of their extenſion. They have pores that imbibe the juices of the plant where they are depoſited. Theſe are minute *placentiæ* that tranſmit the nouriſhment to the embryo.

5. The diſtinction of inſects into *viviparous* and *oviparous* does not only take place in ſpecies of different claſſes, but likewiſe in ſpecies of the

ſame

ſame germs. There are ſome two-winged flies that are *viviparous*, and others that are *oviparous*.

Add to this, that ſome ſpecies are viviparous at one time, and oviparous at another. The *vine-fretter* furniſhes an example of this.

All great animals that are known to us, are diſtinguiſhed into *males* and *females*, and propagate the ſpecies by copulation. The ſame order prevails amongſt inſects; but all the ſpecies are not ſubject to it, and, of thoſe that are, ſeveral afford us ſome very remarkable ſingularities. In divers ſpecies, the male is *winged*, and the female not. The *glow-worm*, which is ſentenced to crawl during its whole life time, is fecundated by an inſect having four wings.

Sometimes this ſtriking ſingularity is joined with others that are ſtill more ſurpriſing. Every where elſe we obſerve a certain proportion betwixt the male and female; here this proportion vaniſhes entirely. The female is a coloſſus, on which the male walks as on a ſpacious ſpot. The ardor and agility of the male are exceſſive. He is almoſt in continual motion. The female on the contrary, moves but ſeldom, and that heavily. She ſometimes ſpends the greateſt part of her life in the moſt perfect inactivity. In fine, the male is an inſect *properly ſo called*, his whole body is interſected by *inciſions* that are very conſpicuous: the female is a ſpherical maſs, fixed to a branch, that one would be apt to take for an excreſcence or gall nut of this branch. You will imagine that I am ſpeaking of *gall-inſects*, whoſe name ſo well explains their deceitful appearances. They are found in great numbers on the branches of many trees and ſhrubs. They are greatly diverſified; but always affect the form of *gall-nuts* more or leſs round. They imbibe the juice of the tree by the affiftance of a little pump, which they keep fixed to the bark. They lay fome thoufands of eggs, which are piled up under the mother's belly, as they iffue from it. When the whole number is laid, the gall-infect dies, and its carcafe remains faftened to the branch. This is only a cod full of eggs, which one might ftill take for a living gall-infect, fo fmall an appearance of life is there in this ftrange animal. The young are hatched in a fhort time, when there immediately appears a multitude of very fmall animated membranes, either oval or circular, which are borne on fix legs, and difperfe themfelves on all fides with a wonderful celerity.

6. Several of the fpecies that live in fociety, prefent us with three forts of individuals; to wit, *males*, *females*, and *neuters*, or individuals that remain always deprived of fex. This we obferve in the republics of *bees*, *wafps*, and *ants*. We know that each *fwarm* of bees has but one female, which bears the name of *queen*; the males which are called *drones*, pretty often amount to four or five hundred; the neuters, which are much more numerous, are fometimes forty or fifty thoufand in number. Thefe are the *ilotes* of the little fparta; they are charged with all the labour. The queen and drone are wholly taken up in furnifhing the ftate with citizens. She is in a literal fenfe the mother of all her people; fhe lays in one year upwards of fifty thoufand eggs. She produces three forts of them, from whence are hatched three kinds of individuals of different fhape. The neuters then conftruct three forts of cells, to receive the eggs, and lodge the young to be hatched from them.

Divers fpecies of infects are real *hermaphro-*

dites

dites: in each individual both ſexes are united, but he cannot fecundate himſelf; and generation depends in this caſe as elſewhere, on the concurrence of two individuals.

7. Other inſects are *hermaphrodites* of a more ſingular nature; each individual propagates without any commerce with another. We have the firſt example of this in the *vine-fretter*, that deſerves ſome attention.

You have very frequently ſeen little flies faſtened in great number to the upper extremities and leaves of plants, and twiſt them round in various forms: theſe are vine-fretters, whoſe ſpecies are almoſt as numerous as thoſe of vegetables, and whoſe remarkable properties are multiplied in proportion to the attention we pay them.

They bring forth living young ones. Their births are eaſy to trace, there needs only good eyes and a little patience. Take up a little one as ſoon as it is produced: incloſe it immediately in the moſt perfect ſolitude, and in order to be the better aſſured, carry your precautions to a degree of ſcrupulouſneſs; be with reſpect to it a more vigilant Argus than the fabulous one. When the little recluſe has acquired a certain growth, it will begin to have young, and after ſome days you will find it in the midſt of a numerous family.

Make the ſame experiment on one of the individuals of this family that you have tried on its chief: the new hermit will multiply like its father, and this ſecond generation brought up in ſolitude will not prove leſs fruitful than the firſt.

Repeat the experiment from one generation to another; abate nothing of your cares, your precautions, and ſuſpicions; proceed, if your patience will permit you, to the ninth generation,

 and

and they will all present you with fecund virgins.

After these experiments, so decisive and reiterated, you are easily persuaded that there is no distinction of sex in vine-fretters. What indeed would be the use of such a difference amongst a people where all the individuals are constantly sufficient for themselves? Natural history is the best logic, because it best teaches us to suspend our judgment. Vine-fretters are really distinguished by sexes; there are males and females amongst them, and their amours are the least equivocal of any in the world. I do not know whether there are in nature any males more amorous than they.

What then is the use of coupling between insects that multiply without its assistance? of what service can an actual distinction of sex be to real *Androgynes?* The clearing up of this point depends on another great singularity. During the summer season they are *viviparous*; they all bring forth living young. Towards the middle of autumn they become *oviparous*; they all then lay real eggs, which are hatched at the return of the spring. The males begin to appear exactly at the time the females begin to lay. There is therefore a secret relation betwixt the appearance of the males, and the laying of the females. There are always found in the bodies of the females, eggs and young ready to be produced. The young then were originally inclosed in eggs. During the fine season, they are hatched in the belly of their mother, and are brought into the world alive. Plants at that time furnish them with a proper nourishment, which they fail not instantly to imbibe by the help of a very slender trunk. At the approach of cold weather, the young cannot unfold themselves in the dam's

belly

belly, in order to their being produced alive: they remain ſhut up in their eggs, where they are preſerved the whole winter. Were they to be hatched at the beginning of that ſeaſon, they would ſoon periſh for want of food. The developement depends ultimately on nutrition. Vine-fretters that are produced alive, are more unfolded in the matrix than thoſe which are brought forth incloſed in eggs. The former then have received a nouriſhment in the matrix, which the others were not able to obtain there. This nouriſhment was ſufficient to effectuate the entire opening of the germs. Had not coupling, then, for its primary end, the ſupplying the defect of this nouriſhment in ſuch germs as were not to be hatched till after they had iſſued from the belly of their mother?

I have treated of ſome ſpecies of inſects, the males of which are winged, and the females not. This ſingularity is alſo to be met with amongſt Vine-fretters: but they offer ſtill more to us with reſpect to this. Some of the males are winged, and others remain their whole life-time without wings. There are likewiſe winged females, and other females that are not. But this is not all: the males, and particularly thoſe that are deſtitute of wings, are ſo ſmall in compariſon of the females, that they are ſeen to walk upon them as a mite upon fruit; to ſo great a degree has nature thought fit to abound, with regard to theſe inſects, in ſingularities of different kinds.

8. Animals that multiply by *ſlips* and *ſhoots*, and that may be grafted, appear to be real *zoophytes* or *plant-animals*.

Of theſe ſome have *feet* or members, others not. We will firſt treat of the latter ſort.

The ſlime which covers the bottom of ponds and marſhes, may almoſt be deemed a reſpectable thing: there the GREAT BEING has not diſdained to aſſemble the traces of his power and wiſdom. He has connected the exiſtence of this vile matter with that of different ſpecies of worms that are deſtined to live in and feed upon it, and that will one time or other preſent us with the intereſting ſight of a new re-production, which we ſhall never think we can ſufficiently admire, and ſhall therefore wonder at it in proportion as our underſtanding is enlightened.

All theſe worms are long and ſlender. They are not unlike the *treble* ſtring of a violin: their body is formed of the ſucceſſion of a great number of little rings, which decreaſe gradually as they approach the extremities. They are very ſoft; their head, which terminates in a blunt point, is ſuſceptible of various motions. It contracts, dilates, lengthens, and ſhortens itſelf at the pleaſure of the inſect. The mouth is furniſhed with a muſcle that directs the functions of it, and whoſe exerciſe is pretty perceivable. The anus, which is placed at the oppoſite extremity, is a little oblong aperture, bordered with an analogous muſcle. The whole ſkin is ſo tranſparent, as to admit of its being inſpected within, and we may congratulate ourſelves on this circumſtance, ſince it affords us a great ſpectacle. The polypus exhibits nothing that has the appearance of viſcera. All its ſubſtance ſeems to be compoſed of a maſs of ſmall ſimilar ſeeds. Our *fiddle-ſtrings* are minute beings, quite differently organized, and the apparatus of the viſcera, which the microſcope diſcovers to us, ſeems to advance them far above the polypus. A long veſſel that goes winding from the head

head to the tail, is what chiefly ſtrikes the eye of the obſerver. By its regular alternate motions, he will ſoon know it to be the heart, or grand artery. The liquor that circulates in theſe winding paſſages is limpid. It is perceived from the pulſations it excites in every part of the artery comprized betwixt two of the rings. One would be apt to imagine each of theſe portions to be a real heart, and that every artery was a chain of little hearts, placed end to end, and that forced the blood from one part to another. It is ſeen to run with an uniform motion through all theſe little hearts, and riſes in this manner as by ſo many bladders from the tail to the head, near which it finally diſappears. In different parts of the artery are diſcovered delicate ramifications of veſſels, which may be taken for veins, there being perceived no pulſation in them. Beneath and along the artery there is a canal, whoſe diameter varies at different points of its extent. It is the inteſtinal duct, which comprehends the œſophagus, ſtomach, and inteſtines. The aliment is there ſeen to digeſt before the eyes of the obſerver: he follows it in its paſſage: ſees it deſcend from the mouth towards the anus, and paſs through every part of the canal between theſe two extremities. But can machines ſo compounded as theſe be taken to pieces without injuring their œconomy thereby?

That ſuffers not in any reſpect on that account. Strictly ſpeaking it affects theſe inſects no more than being divided in the midſt of the body. Each half not only continues to live and move; but that which had no head preſently forms another, and we may clearly perceive a new tail ſpring forth in that part which was deſtitute of one. In leſs than three days the two moieties become two complete worms.

It is more extraordinary for fourths, eighths, and ſixteenth parts of our worms to aſſume a head and tail: this is ſo ſpeedily effected, that in a few days all theſe fragments are ſo many perfect inſects, and after a few weeks attain to the ſame length as the intire worm. New rings and new viſcera unfold themſelves, the parties re-produced differ in no reſpect from the antient ones. Thus the machine is formed anew by its own ſtrength; and the ſection, which might be a means of deſtroying them, ſerves only to make them conſpicuous.

I have not yet ſufficiently treated of this particular. The ſix and twentieth part of worms, to wit, perfect atoms, are able to *re-integrate* themſelves extremely well, and in the ſpace of ſome months are found to be worms of ſeveral inches in length. In theſe living atoms, as well as in the moſt conſiderable fragments, the circulation ſeems to be performed with the ſame regularity as in the whole worm. Each atom has its little heart, and we may clearly perceive that this little heart is no other than a very ſmall portion of the grand artery of the worm, whereof the atom was before a part.

We may weary ourſelves in cutting the head off the ſame individual; we ſhall have the ſame taſk to repeat continually, becauſe there always ſhoots forth a new one. We may even cauſe ſeveral to iſſue at the ſame time, each of which ſhall have their proper functions.

There is another ſpecies of theſe worms, amongſt which the property of becoming again entire is confined in very remarkable bounds. It forms a head or tail in the middle; but if it be cut into three or four parts, the *intermediate* ones

ones puſh forth a tail where a head ſhould have been produced. This ſuperumerary tail, which is in no repeƐt deficient, cannot perform the office of a head, and the unhappy inſeƐt is condemned to periſh with hunger.

9. Look into this rivulet, whoſe bottom is covered with broken pieces of plants: what do you perceive upon them? Spots of mouldineſs; do not miſtake: this mouldineſs is not what it appears to be: and you already begin to ſuſpeƐt ſo: you think that you greatly ennoble them by advancing them to the rank of vegetables: you conjeƐture they are plants in miniature, that have their flowers and ſeeds, and plume yourſelf on being able to judge of theſe mouldineſſes in a different manner from the vulgar. Take a magnifying glaſs: what do you diſcover? Some very pretty noſegays, all the flowers of which are *in bells*. Each bell is ſupported by a ſmall ſtalk, which is implanted in a common one; you now no longer doubt of the truth of your conjeƐture, and cannot be perſwaded to quit this microſcopic parterre. You have not however ſufficiently obſerved it. Look ſtedfaſtly on the aperture of one of theſe bells: you will there perceive a very rapid motion, which you cannot be weary of contemplating, and which you compare to that of a mill. This motion excites little currants in the water, that convey towards the bell a multitude of corpuſcles, which it ſwallows up. You begin to doubt whether theſe bells are real flowers; and the motions of the ſtalks, which appear to be ſpontaneous, increaſe your ſuſpicions. Continue your obſervations: nature herſelf will teach you what you ought to think of this ſingular produƐtion, and will furniſh you with freſh

fresh motives for admiring the fecundity of her ways. That is a bell which detaches itself from the cluster, and that floats along in order to fix itsel to some support. Follow it. A short pedicle issues from its extremity: and the bell fastens itself by the end of this pedicle. It lengthens and becomes a little stalk. It is no longer a nosegay you are beholding, 'tis a single flower. Redouble your attention; you are just arrived at the most interesting moment of inspection. The flower is closed, has lost its form of a bell, and assumed that of a bud. You perhaps suspect that this bud is some fruit, or a seed that has succeeded to the flower: for you are loth to give up your first conjecture. Do not lose sight of this bud; it is now divided by degrees according to its length, and the stalk is at present supplied with two buds, less than the first. Examine what passes in both of them. They widen themselves insensibly, and you perceive a motion at the edge of the opening, which increases in swiftness in proportion as the bud unfolds itself. The mill appears again, and the two buds have assumed the form of a bell. Can a fruit, which changes into flowers, be a real fruit? Can such flowers be real flowers? that swallow little insects? Suspend your observations, and repeat them a few hours hence. Your flowersare closed up as the first was; you easily guess that they will separate themselves as before, afterwards open, and present you with four bells. That is already effected, and you have a little nosegay, composed of four flowers. If you continue your inspection, you will see them augment in bulk by new divisions into two's, and soon after you will count sixteen, thirty-two, sixty-four flowers. Such is the origin of this microscopical parterre, which at first drew your attention:

attention: how much more admirable does it now appear than you then conceived it to be! What a group of wonders does a ſingle ſpot of mouldineſs afford! What unforeſeen, varied, and intereſting ſcenes, are tranſacted on a ſcrap of rotten wood! What a theatre does it exhibit to a thinking being! But our abode is ſo recluſe, that we have but a glimmering view of it; how great would our raviſhment be, if the whole ſpectacle diſcloſing itſelf at once to us, we ſhould be enabled to penetrate into the interior ſtructure of this wonderful aſſemblage of living atoms! Our blunted eyes diſcover only the moſt ſtriking parts of them; they only apprehend the groſs parts of the decorations, whilſt the machines that execute them remain concealed in impenetrable darkneſs! Who ſhall enlighten this profound obſcurity? Who ſhall dive into this abyſs where reaſon itſelf is loſt? Who draw from thence the treaſures of wiſdom and knowledge concealed within it? Let us learn to be content with the ſmall portion communicated to us, and contemplate with gratitude thoſe firſt traces of human underſtanding imparted to us, towards a world placed at ſuch a great diſtance from us.

10. You cannot quit this ſpring, from whence you have derived ſo many truths, that are ſo aſtoniſhing. You diſcover in it other microſcopical animals, whoſe form reſembles that of a funnel. Theſe are likewiſe polypus's. They do not compoſe a cluſter; but cleave to ſome body by their inferior extremity; you are curious to know their method of multiplying. In order to this, place your microſcope on one of theſe funnels. Of a ſingle funnel, there are formed two by a natural diviſion; but very different from that of bell poly-

pus

pus's; ſo far has nature thought fit to vary her proceedings with reſpect to theſe animals. Examine what paſſes in the middle of the funnel. A tranſverſe and oblique ſtripe indicates to you the part where the polypus is about to divide itſelf. The diviſion then is made ſlopingly. The ſtripe points out the edges of the new funnel, and theſe are only the lips of the freſh polypus. You diſcover in them a pretty ſlow motion, which helps you to diſcern them. They approach each other inſenſibly, the body collects itſelf by degrees; a little ſwelling forms itſelf on the ſide, which is a new head. You already clearly diſtinguiſh two polypus's placed above each other. The upper polypus has the former head and a new tail; the inferior one a new head and the former tail. The upper polypus is connected with the other only by its lower extremity. By a motion it gives itſelf, it is at laſt detached from the other; and floats away in order to fix elſewhere. The inferior polypus remains faſtened to the place where the funnel was before the diviſion.

11. Net polypus's likewiſe derive their name from the exterior form of their bodies; they pretty nearly reſemble that of a fiſhing-net. They aſſemble in groups, and faſten on all the bodies they meet with in freſh water. They are very tranſparent. In the inſide of the polypus there is formed an oblong and whitiſh body. As ſoon as it is formed, it deſcends by degrees, ſhews itſelf on the outſide, and remains fixed perpendicularly on the polypus. It produces new ones every day; and the group they compoſe on the exterior part of the polypus, increaſes in growth. If theſe minute bodies be *eggs*, they are of a ſingular

lar ſpecies, they are abſolutely without any covering, and are neither membraneous or cruſtaceous. We cannot affirm of theſe eggs, that young are hatched from them, but are under a neceſſity of acknowledging, that theſe little *oviform* bodies unfold themſelves. This developement is accompliſhed in a few minutes, and the polypus becomes the ſame as its mother: imagine to yourſelf a bird that ſhould iſſue from its mother's belly, intirely naked, rolled together like a ball, whoſe members ſhould afterwards diſplay themſelves, and you will have a repreſentation of the production of net polypus's.

12. Cluſter-polypus's propagate by dividing in the middle; *arm*-polypus's do not multiply in this manner. They bring forth their young almoſt as a tree ſhoots forth its branches. A little bud appears on the ſide of the polypus. Do not ſuppoſe that this bud contains a polypus, as the vegetable bud comprizes a branch : it is itſelf the polypus in its growth. It increaſes in ſize and length, and at laſt ſeparates from its mother. Whilſt it is united to her, they both compoſe one body, as the branch with the tree. You are to underſtand this in the ſtricteſt ſenſe. The prey which the mother ſwallows, paſſes immediately into her young, and imparts the ſame colour to it. So that the whole conſiſts of one little bowel in a great extent. The prey which the young one ſeizes (for it fiſhes for it as ſoon as it has arms) paſſes in like manner into the mother. They nouriſh each other reciprocally.

There is ſcarcely any polypus without buds. All of them therefore are ſo many polypus's, or ſo many ſhoots that grow on a common trunk.

Whilſt they are unfolding, they themſelves ſend forth ſmaller ſhoots, and theſe ſmaller ſtill. They all extend their arms on both ſides. You think you are beholding a very buſhy tree. The nouriſhment received by one of theſe ſhoots, is ſoon communicated to all the reſt, and to their common mother; the chief of the ſociety and the members are one. The ſociety is diſſolved by little and little, the members ſeparate themſelves, are diſperſed, and each ſhoot becomes in its turn a little genealogical tree.

Such is the natural method by which the arm-polypus multiplies. It may alſo be multiplied by ſlips. There is no need to mention, that when it is cut in pieces, each piece in a ſhort time becomes a perfect polypus. It were better to ſay at once, that the polypus, after being cut into ſmall pieces, riſes again from its ruins, and the little fragments yield as many polypus's. Being cut either in length or width, this extraordinary animal is re-produced in the ſame manner, and the ſources of life are equally inexhauſtible.

13. But the following is what fable itſelf has not preſumed to invent: bring to their trunk the heads that have been ſtruck off, they will re-unite to it, and you will reſtore to the polypus its head. You may alſo, if you think proper affix to it the head of another polypus. The mutilated parts of the ſame or different polypus's, when placed end to end, will unite in like manner, and form only a ſingle polypus.

What have I hitherto ſaid? There is ſcarce any miracle that may not be performed by means of the polypus; but miracles, when multiplied to ſo great a degree, hardly appear to be ſuch. A polypus

polypus may be introduced by its hind part into the body of another polypus. The two individuals unite, their heads become ingrafted into each other; and the polypus, which at first was double is converted into a single polypus, that eats, grows and multiplies.

I have compared the polypus to the finger of a glove: this finger may be *turned inside out:* so may the polypus likewise, and being so *shifted*, can fish, swallow, and multiply by slips and shoots.

It will be easily believed that the polypus does not like to remain thus shifted. It make an effort to regain its former position, and frequently succeeds either in part, or altogether. The polypus, which is partly turned back again as at first is a real Proteus, that assumes all kinds of forms, which are all equally strange. Endeavour to represent to yourself the polypus thus turned again. You remember that the insect is made in the form of a bowel. One part of the bowel then is turned backwards on the other; it there fastens and engrafts itself. In that case the polypus is as it were doubled. The mouth encompasses the body like a fringed girdle; the arms are the fringe. They then point towards the tail. The fore-part continues open; the other is usually shut up. You expect no doubt to see a new head and new arms to grow out of the fore-part; which you have observed in all the polypus's that have been divided transversely. But the polypus combines itself a thousand different ways, and each combination has its consequences, which experience alone can discover to you. The fore-part closes itself; it becomes a supernumerary tail. The polypus, which was at first extended in the right line, is

curved

curved more and more. The supernumerary tail lengthens every day. The two tails resemble the feet of a pair of compasses. The compasses are partly open. The ancient mouth is at the head of the compasses. This mouth, which is fastened to the body, and embraces it like a ring, cannot discharge it functions. What then must become of the unfortunate polypus with two tails and without a head? How will it be able to live? Do you think that you have taken nature at unawares? You are mistaken. Towards the upper part of the polypus, near the ancient lip, there are forming not only a single mouth, but several; and this polypus, concerning which you inquired a minute ago how it could exist, is now a species of hydra with several heads and mouths, and devours with all these mouths.

14. What a multitude of physiological truths, that were unknown to us in the vegetable kingdom, has the *arm*-polypus alone unveiled to us? How do these truths appear as paradoxes, and yet how evidently are they demonstrated? Who can doubt now that there exists an animal, a very animal, since it is extremely voracious, whose young grows like branches, and which being cut to-pieces and actually minced, regenerates a new in all its parts, and even in the smallest fragments, that may be grafted by *approximation* or *inoculation*, turned inside outwards like a glove, afterwards cut, turned back and cut again, without ceasing, to live, devour, grow, and multiply.

It was not a fit season therefore to make *general rules*, to arrange nature, establish distributions, form systematical orders, and to raise an edifice, which future ages, better instructed, will even dread to project. We have scarce any knowledge of of the animal, when we would undertake to define it. Becauſe our knowledge is at preſent in ſome meaſure improved, ſhall we preſume to think we thoroughly know it? Polypus's have aſtoniſhed us, becauſe on their firſt appearance there was no idea in our brain analogous to them, and we had taken great pains to diſcard from it the very poſſibility of their exiſtence. How many animals are there that are even more ſtrange than polypus's and that would confound all our reaſonings, could we diſcover them? It would be neceſſary on that occaſion to invent a new language, in order to deſcribe our obſervations. Polypus's are placed on the frontiers of another univerſe, that will one time or other have its COLUMBUS's and VESPUTIUS's. Shall we imagine that we have penetrated into the interior parts of the continents, becauſe we have taken a ſlight view of ſome coaſts at a diſtance? We will form to ourſelves more exalted ideas of nature; we will conſider her as one immenſe whole. and will firmly perſuade ourſelves that what we diſcover of her is but the ſmalleſt part of what ſhe contains. Having been heretofore aſtoniſhed, we will forbear being ſo for the time to come,but will continue our obſervations; we will amaſs freſh truths, connect them if we are able, and be in expectation of every diſcovery, becauſe we will continually ſay, that the known cannot ſerve as a model for the unknown, and that models have been varied *ad infinitum*. *Cluſter* polypus's multiply by dividing themſelves; who can tell but that there may one time or other be diſcovered animals, that inſtead of dividing themſelves, may unite together, and join themſelves to one another, in order to compoſe one ſingle animal? Or who knows whether the multiplication of ſuch an animal may not have as an eſſential condition, the

the confolidation of feveral animalcules in a fingle one? We fay that an animal muft have a brain, an heart, arteries, veins, nerves, a ftomach, &c. Thefe are the ideas we have deduced from large animals, and we carry them every where with confidence. We act herein like a French traveller, who fhould expect to find in the *Terræ Auftrales* the modes of his own country, and that would be greatly chagrined on being difappointed. The animal kingdom has alfo its *Terræ Auftrales*, in which probably it is not cuftomary to meet with a brain, an heart, a ftomach, &c. Why do we defire that nature fhould always condefcend to form one animal with the elements of another? She might indeed be conftrained fo to do, did not her fecundity furpafs that of our poor conceptions? But the HAND, which has formed the polypus, has demonftrated to us, that IT can, when neceffity requires, *animalize* matter at a much lefs expence. IT has defcended by almoft infenfible degrees from thofe great organized maffes we call quadrupeds, to thofe minute organized bodies we ftile *infect*; and by gradual and fkilfully contrived fubtractions, it has at length reduced animality to her fmalleft terms. We are unacquainted with thefe fmalleft terms. The polypus, fimple as it appears to be, is without doubt very much compounded, in comparifon of fuch animals as are placed beneath it in the fcale. It is, if we may be allowed the expreffion, too much an animal, to be the laft term of animality. We know that the brain is the principle of the nerves, that it filtres the fpirits; that the nerves are the organ of feeling; that the heart is the primum mobile of circulation; that the veins and arteries are the dependancies, all this we have feen in great animals, we have again to our furprize found it in infects: though

though under different forms: we were thus accustomed to regard these various organs, and some others, as essential to the animal. The polypus, however, exhibits to us nothing similar; the best microscopes only discover to us an infinite number of small disseminated seeds in its whole substance: and the unforeseen experiment of its *shifting*, sufficiently proves that there is nothing in its structure common to that of animals before known to us. Were we not capable of imagining, that an animal had been endued with the property of being propagated and grafted like a plant, it would have been much less possible for us to suspect that there had been granted to it the power of being turned inside out like a glove. The *arm*-polypus, is nevertheless a perfect animal; its voracity is excessive; it devours all the little insects that happen to touch it, and seizes them with such skill, as seems to give it an affinity to hunting animals. The *cluster* polypus quite differently constructed, has not the same advantages, but has relative ones: it can excite a rapid motion in the water, which brings towards it those living corpuscles it feeds upon. There are undoubtedly many animals that are still much more disguised than the *cluster*-polypus, and by not affording us any *exterior* sign of animality, leave us for a long time uncertain of their true nature. When a *bulb* of such a polypus is detached from it, and fixes it by its short pedicle to any support, should we be apt to consider it as an animal production: has not the *gall-insect* been taken for a real vegetable gall-nut by such observers has had not seen it in its primitive state? Is not the pond muscle deficient in many things we judge to be necessary for the animal? How many shell-fish are still farther degraded? Nay more, there may probably exist some

ſome animals, which it would be impoſſible for us to acknowledge as ſuch, even though their whole ſtructure, as well internal as external, ſhould be laid open to us; the reaſon is, that judging only according to our preſent notions, we cannot deduce from this ſtructure the opinion of life.

15. I cannot yet quit this ſubject. We are not able to conceive all the methods by which the AUTHOR of nature has given life and ſenſation to a prodigious number of different beings. Let us judge of them at leaſt by a compariſon of a ſmall number of animated beings we are acquainted with. How greatly does life differ in the ape and the bell-polypus? What intermediate degrees are there betwixt theſe two terms? Perhaps there are ſtill more from this polypus to the laſt of animals. I do not examine if ſouls have been varied like bodies; but I conceive that organized matter has been modified infinite ways, to which have correſponded as many different methods of participating life and ſenſation. I likewiſe conceive that the ſame ſoul, if placed ſucceſſively in all the organized bodies that exiſt, would ſucceſſively experience all the poſſible modifications of life and ſenſibility. This ſoul would paſs through all the degrees of animality; and if ſhe could remember them all, and compare them, ſhe would equal the ſuperior intelligences in knowledge. She would contemplate our world through all thoſe glaſſes that have been given to the various beings that inhabit it.

16. Let us draw a general conſequence from all this: that *analogy*, which is one of the great lights of phyſics, is not capable of diſſipating the ſhades of it. This light is frequently extinguiſhed on the

the approach of certain bodies which we bring to the touch of experiment. To what purpose does analogy serve in the examination of the *bulb*-polypus? We cannot even define these *bulbs*; and does the name we give them express any thing more than mere appearances? How can analogy enlighten us concerning the nature of these minute bodies, and the manner by which they are engendered and ingender, whilst she offers nothing to us either in the vegetable or animal kingdom, which bears the least relation to these productions, so different from all those that were known to us? I affirm as much with regard to the natural division of the *bells*, and of the *shifting* of the arm-polypus's. This is an intire new order of things, which has its particular laws, which we should in all probability be able to discover, could we find some means of penetrating into the secret mechanism of these little beings. We should then discern all the sides by which they are connected with other parts of the organical world.

17. When we consider in a general view the composition of men and quadrupeds, we shall presently discern that there is with respect to all of them the same foundation of structure, differently modified in different species. In order to be convinced of this, we need only cast our eyes on those anatomical plates, in which are represented the skeletons of divers animals that have been dissected. From man, the ape, and horse, to the squirrel, weasel, and mouse, we shall see throughout, the same design, the same arrangement, the same essential relations, except in a few particulars. The spine, which is formed of a series of parts jointed to each other as by so many hinges, bears to its upper extremity a sort of bony box,

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of greater or leſs extent. Some bony arches, which on one ſide are connected with the ſpine, and on the other with a part oppoſite to it, form another more ſpacious box. The upper and lower extremities are joined likewiſe to the ſpine by different interpoſed bands, and maintain the body in thoſe various attitudes its exigencies require. This œconomy is ſo generally obſerved, that it has even been remarked that the vertebræ of the neck are ſeven in number in all the ſpecies. Almoſt the ſame order is to be met with in birds and fiſhes. It varies more and more in reptiles, ſhell-fiſh, and inſects. The latter however have their bones, ſeveral parts of which ſeem to imitate the correſponding ones in great animals; but whereas among the latter the fleſh covers the bones; on the contrary, among inſects the bone covers the fleſh. In this numerous claſs of little animals, nature has in an eſpecial manner *diverſified* her models the moſt, and diſplayed the wonderful fecundity of her inventions. In the large parts of the animal kingdom ſhe pretty nearly purſues the ſame plan of architecture, and hardly diverſifies any thing but the orders. In one we behold the ſtrength and majeſty of the *Tuſcan*; in others the elegance and delicacy of the *Corinthian*. But when ſhe deſcends to inſects, ſhe ſeems intirely to change her plan, and to retain as little as poſſible of her firſt models. She ſeems at length to abandon them altogether in her formation of an *arm* or *bell*-polypus. She conſtructs plants on ſtill different models; but theſe models retain in them ſomething of the organization of animals, and particularly that of inſects. The organs of reſpiration are almoſt the ſame in the plant and inſect. Thoſe parts which are eſſential

eſſential to life are diſperſed throughout the whole body of the plant, as they are in inſects, that are reproduced by ſlips. Thoſe plants which appear to be moſt elevated in the ſcale, exhibit to us a ſtalk, branches, roots, leaves, flowers, and fruit. A ſwine-bread, an agaric, a liverwort, on the contrary, are ſo extremely diſguiſed, and have in them ſo ſmall a reſemblance to plants, that it is neceſſary to have the eye of a ſtrict obſerver, in order to know and characterize them. Theſe half vegetable productions, if I may be allowed the phraſe, ſeem, in the vegetable kingdom to be what the gall-inſect, polypus, and the muſcles are in the animal. They do not appear to be more organized than an amianthus, a talc, or a cryſtal.

18. The diſtance however is much greater from the moſt regular foſſil, or that moſt reſembling a vegetable, to the plant in the leaſt degree ſo, or that is the leaſt organized. The foſſil does not *grow*, properly ſpeaking; it does not receive *nouriſhment*, nor engender. It is formed of the ſucceſſive *appoſition* of different molecules, which by uniting together under certain relations, determine its figure. The plant is a body truly organized, which of itſelf works the molecules, deſtined ed to incorporate themſelves with its ſubſtance, and to extend it every way, and contains little bodies reſembling it, which it nouriſhes, cauſes to expand themſelves, and by means of which it multiplies its being. Nature then ſeems to make a great chaſm in paſſing from the vegetable to the foſſil. &c. There are no bands, no links hitherto known to us, which unite the vegetable to the mineral kingdom. But ſhall we form our judgement of the chain of beings by our preſent degrees

of knowledge? Because we here and there discover in it some interruptions, some void spaces, shall we conclude from thence that they are real? Shall we imagine that a comet has split the scale of our world, and destroyed the harmony of it? We are only beginning to survey the vast cabinets of nature; and amongst that innumerable multitude of various productions which she has assembled, how many are there which we have not so much as seen, and can frame no idea of their existence? Shall we hasten to decide concerning the result of these productions before we have examined them all, or formed an exact list of them? The vacancy we suppose left betwixt the vegetable and mineral, will in all probability be one day supplied. There was a similar void betwixt the animal and vegetable: the *polypus* now fills it up and sets in a conspicuous light the admirable gradation there is among all beings. It is true we can't form any *mean* idea betwixt the plant and the fossil; we do not imagine there is any shadowing between *growth* and *apposition*: but had we formed any conception of the properties of the *polypus*? If those marine productions, which have been called *stony* plants, were real plants, they were in some measure one of the links requisite for uniting the vegetable to the mineral kingdom. But late discoveries have informed us, that these pretended plants are only works of certain polypus's, that have the art of constructing cases for themselves. Those coral flowers, so much celebrated, were real polypus's, and this is another truth wherewith the polypus has enriched the physical world.

19. Organized bodies are tissues which are more or less fine pieces of net-work, or pieces of stuff, whose

whose *warp* itself forms the *woof*, by an art which we should think we could never enough admire, were we acquainted with it. *Fossils* are a kind of *inlaid* work. We do not know where the organization ends, nor which is its smallest term. But by ceasing to organize, nature does not cease to dispose and arrange. She even seems to organize when she has made an end of doing so. One would be ready to imagine that *fibrous* and *leaved* stones were vegetables in part disguised. The constant regularity of *salts* and *chrystals* strikes us in an equal degree. We may be assured, that the crystal is formed of the repetition of an infinite number of small, regular and pyramidal bodies, properly laid on each other, which represent, in some measure, the whole exactly in miniature. We should, notwithstanding, be very much mistaken, were we to consider these little pyramids as the *germ* of the crystal; it is strictly speaking no more than an *element* or constituent particle of it. It does not unfold itself, it remains as it was; but it serves as a support to other similar pyramids which are to be joined to it, and thus to augment the crystaline mass by successive *aggregates*. The crystaline juice is not received, wrought, and assimilated by strainers or vessels that are more or less fine, or more or less folded together, within the pyramid; it is already intirely prepared when it procures the union of different molecules into one pyramidal mass, by virtue of the laws of motion and attraction. This is the primary character which distinguishes brute from organized bodies; a character which we ought never to lose sight of, when we compare together beings of these two classes.

20. Thus the bodies of plants and animals are species of *looms*, machines more or less compound-

ed, which convert into the proper ſubſtance of the plant or animal the various matters ſubjected to the action of their ſprings and liquors. Theſe machines, which are ſo ſuperior in ſtructure to thoſe of art, ſeem ſtill more ſo when compared in their eſſential effects. Thoſe matters which organical machines work, they likewiſe *aſſimilate* and incorporate with themſelves; they *grow* by this incorporation, augment in their dimenſions every way, and during their growth, all their parts preſerve among themſelves the ſame relations, the ſame proportions, the ſame exerciſe; all continue to diſcharge their proper functions; the machine remains in its extended ſtate, what it was in miniature. It is a ſyſtem, a wonderful aſſemblage of an almoſt infinite number of tubes, differently formed, calibered, and interwoven, that like ſo many filtres, purge, faſhion, and refine the nutritious matters. Each fibre, what am I ſaying? Each fibrilla is in itſelf a machine in miniature, which by performing analogous preparations, appropriates to itſelf the alimentary juices, and gives them the arrangement ſuitable to its form and their functions. The whole machine is in ſome meaſure only the repetition of all theſe *leſſer machines*, whoſe united ſtrength conſpires to the ſame general end. The excellence of organical machines appears in a conſpicuous light from other ſtill more ſtriking inſtances. They not only produce, from their own foundation, machines ſimilar to them, but a great number of them reproduce of themſelves thoſe parts they had been deprived of, which various parts become afterwards as many machines, equally perfect with thoſe whereof they before made only a part.

21. To

21. To conclude: the ſame general deſign comprizes all parts of the terreſtrial creation. A globule of light, a molecule of earth, a grain of ſalt, a particle of mouldineſs, a polypus, a ſhell-fiſh, a bird, and a quadruped, man, are only different ſtrokes of this deſign; and repreſent all poſſible modifications of the matter of our globe. My expreſſion falls greatly beneath reality: theſe various productions are not different ſtrokes of the ſame deſigns; they are only ſo many various points of a ſingle ſtroke, that by its infinitely varied circumvolutions, traces out the aſtoniſhed eyes of the *cherubim*, the forms, proportions, and concatenation of all earthly beings. This ſingle ſtroke delineates all worlds, the *cherub* himſelf is a point of it; and that ADORABLE HAND which drew this ſtroke, alone poſſeſſes the method of deſcribing it.

CHAP.

CHAP. IX.

Continuation of Animal Oeconomy conſidered in Inſects.

1. IN the ſeventh chapter you have ſeen the *earth-worm* regenerate; you have contemplated the progreſs of this regeneration; you have remarked a little bud that grew at the fore-part of the ſtump, which unfolding itſelf by degrees, became a vermiform appendage, a kind of little worm, that ſeemed to be ingrafted on the ſtump.

This animal bud has diſcovered to you the firſt origin of the part that is re-produced. You have perceived that it was lodged in miniature under the fleſhy parts of the ſtump, and that the latter does not contribute more towards this production than the earth does to the plants that have taken root in it.

Thus the earth-worm contains, like the polypus, a multitude of germs, which begin to unfold themſelves as ſoon as certain accidents convey towards them the nutritious juices. The ſources of reparation are here in proportion to the accidents that may threaten the animal. But the re-production of the earth-worm is much more aſtoniſhing than that of the polypus. It is not only an enormous coloſſus in compariſon of the polypus, but its ſtructure is alſo much more compounded. It affords a more numerous apparatus of viſcera, veſſels, tra-

cheæ

cheæ, muſcles, &c. It has real blood, and this blood circulates. But it is beſides an *hermaphrodite*; it unites at once all the organs peculiar to the two ſexes. This inſect, which in appearance is the moſt contemptible, would alone be ſufficient to exhauſt the ſagacity of the ableſt obſerver, though applying himſelf ſolely to the contemplation of it. What a gainer would phyſiology be from ſuch an enquiry,? What a number of truths, concerning which we ſhould have no doubt, would then augment the treaſures of our phyſical knowledge?

2. The regeneration of freſh water worms preſents us with the ſame phænomena as that of the earth-worm, and their ſtructure is likewiſe very much compounded, Several ſpecies of them are principally diſtinguiſhed by their colour. All of them do not poſſeſs in the ſame degree the property of multiplying by *ſlips*. In general, the polypus greatly ſurpaſſes them in this reſpect; perhaps, becauſe its ſtructure is more ſimple; and it may alſo be owing to its having a more ample proviſion of germs. Be that as it may, when we cut off the head or tail from the worms we are treating of, they do not themſelves become worms; but all or the greateſt part of the intermediate pieces, how ſmall ſoever they be, very eaſily regenerate themſelves, and in a ſhort time produce an equal number of compleat worms.

Regeneration begins by a little puffing up of the anterior extremity: this puffing ſeems analogous to the vegetable roll. The wound cloſes and quickly, conſolidates. A little bud appears in the center of the roll. This bud increaſes in in ſize and length by degrees. New rings and new viſcera begin to appear. You ſee from the reſt what is to follow.

You alſo very eaſily comprehend after what manner each piece vegetates of itſelf. It has in miniature the ſame viſcera as the whole exhibited at large. You have not forgot that the parts eſſential to life are here diſperſed throughout the whole body, and that circulation is performed in the ſmalleſt pieces as in the whole worm.

Little buds or tubercles ſometimes riſe on the bodies of theſe worms, and give room to think that they are young ones growing from them, *ſlips* reſembling thoſe of the polypus, having the ſame origin and end.

This ſpecies of worm, from certain pieces of which a tail ſhoots forth in the part where a head ſhould have been produced, affords a very ſingular phænomenon, which the frequency of it does not permit us to conſider as the mere effect of chance. It alſo proceeds leſs from chance than the production of this ſupernumerary tail. It is too well organized not to have the ſame origin as that which ſhoots forth at the poſterior extremity. But we cannot pretend to ſay what are the cauſes which here determine a tail to take the place of a head. We only know, that this kind of worm is very much expoſed to the loſs of its hind part: it is therefore in all probability furniſhed with more means for repairing this loſs, than that of the fore-part.

3. It would ſeem as if nature had propoſed to herſelf a kind of diverſion in the formation of inſects. She has laviſhly beſtowed on them members and organs, which ſhe has diſtributed but

ſparingly

ſparingly to other animals; to one ſhe gives two hundred legs; to another twenty thouſand eyes; to a third ſeveral hundred lungs, &c. The production of new legs, new rings, a new head, and new viſcera, ſeem in theſe inſtances to be attended with no greater labour or difficulty than the production of new hairs or new feathers.

She often likewiſe diſguiſes the ſame inſect, and preſents it to us ſucceſſively under ſuch oppoſite forms, that they ſeem to compoſe ſo many diſtinct beings. This leads us to the *metamorphoſis* of inſects.

4. We have had frequent occaſion to acknowledge, that the proceedings of nature are not always uniform, and that ſhe can accompliſh the ſame end by very different ways. Look at this little oblong, black, ſmooth, and ſhining cone. It moſt reſembles thoſe cones which many inſects conſtruct to metamorphoſe themſelves in. However, it differs from them in ſome eſſential particulars. View it through a microſcope; you will then perceive in it ſome annular inciſions, but not very deep, which diſcover to you its true nature, and at the ſame time informs you, that it is nothing but the ſkin of a worm, which is become round, and has contracted a hardneſs. Open it gently with the point of a needle, you find nothing in it but a kind of pap, in which you are able to diſcover nothing. The inſect has but lately loſt its form of a worm; how has it been reduced into that ſoft ſubſtance? How will that become an inſect? Suſpend your queſtions, and open a cone that is leſs recent than this. What do you diſcover in it? A little maſs of oblong whitiſh fleſh, in which

you cannot perceive, even through a magnifying glafs, the leaft fign of members or organs. In a word you have before you an *oblong ball.* Do not imagine that this ball is a cafe that contains a nymph: it is itfelf a nymph that is much difguifed. Prefs the ball a little: the legs begin now to fhow themfelves: they come out of a little focket, that is at one of the extremities of the ball. Augment the preffure by degrees; you will force all the parts of the nymph to appear. They therefore exift already; but they were funk and infolded within the ball, almoft as the fingers of a glove might be in the hand of the glove.

If you could make the fame experiment on the *oviform* bodies of *net*-polypus's, and on the buds of *arm*-polypus's, that you have lately made on the *oblong ball*, you would probably oblige the little polypus to produce itfelf, and by that means accelerate the time of its birth.

5. Infects that pafs through the ftate of an *oblong ball* can therefore form themfelves a cone of their own fkin. All the parts of the nymph feparate themfelves by little and little from this fkin. It grows round and hard about them; and under this fingular arch they make an end of perfecting themfelves. They are at firft only of the confiftence of a pap. This thickens by degrees. It affumes the form of an oblong ball; and when all the members of the nymph have acquired a certain confiftence, they iffue one after another from the infide of the ball, and arrange themfelves like thofe of other nymphs.

By becoming a kind of cone, the fkin of the infect does not lofe in all the fpecies, the form that was proper to the worm; fome of them pre-

ferve

ſerve it ſo well, that the metamorphoſed worm ſcarcely differs at all from the worm that has not been yet transformed.

6. A hen that ſhould lay an egg as large as herſelf, from which a cock or a hen would be hatched, may offer to us ſuch a prodigy, as we ſhould find ſome difficulty in believing. A fly that is troubleſome to horſes, and whoſe form has cauſed it to be named the *ſpider-fly*, affords us ſuch a prodigy; and it ſhould not ſeem the leſs ſtrange, becauſe it takes place only in an inſect. Were there a law in the organical kingdom, to which we knew no exception, it would aſſuredly be that which ordained every organized body to grow after its birth. Nevertheleſs, here is a fly that lays a ſpecies of egg, from which is produced another fly as large and as perfect as the mother. This egg is almoſt round, white at firſt, and afterwards of a black or ebony colour. The ſhell is firm and poliſhed—but I muſt undeceive my reader: this is not a real egg, but has only the appearance of one; it is the inſect itſelf that has aſſumed the form of an *oblong ball*, in a cone made of its own ſkin. The thing is not the leſs wonderful on that account. All inſects that metamorphoſe themſelves go through their various transformations, out of the belly of their mother. They are indeed to grow conſiderably before they undergo their firſt transformation, but do not grow at all afterwards. We have then an inſect that transforms itſelf in the very belly of its mother, and acquires no farther growth after it has iſſued from it.

Theſe cones of the ſpider fly, theſe pretended eggs have been opened at different times; and in them

them have been found the same things that are discerned in the *oblong ball*-nymphs, when observed at their different ages. Moreover, there have been discerned *stigmata* in this species of cone that might be taken for a real egg, which is an evident proof that it was the skin of a worm that has transformed itself under this very skin. An egg is without motion: our cone has some that are very visible, and in certain circumstances the inside admits of their being seen, which attracts the attention of the observer. He seems to discern little clouds that succeed each other without interruption, and that pass with a progressive and uniform motion, from one end of the cone to the opposite one. In the cones that are laid before the time, these shadowy layers have a contrary direction from that which they have in the cones at the full time. You have seen that the circulation varies its course in the nymph: since our shadowy layers change their's likewise, they pretty clearly indicate to us, that the abortive cone is the worm itself, that has not yet gone through its metamorphosis. This worm is in truth a very singular being; it has neither head, mouth, nor any member: it is in appearance nourished like the eggs of birds, in the *trunks* that inclose them. A nice dissection demonstrates the *ovary* of the fly, and the *worm* lodged in the middle.

7. When animals were divided into *viviparous* and *oviparous*, it was thought that all the species were comprehended. The vine fretter came first to clash with this famous division, and convinced us that an animal was at the same time viviparous an oviparous. The *arm*-polypus next appeared, and

and presented us with an animal, that multiplying by *slips*, might with good reason be called *ramiparous*. There have even been observations made which seem to prove that it is likewise oviparous. Another species of polypus, that multiplies also by slips, and is extremely well characterised by a sort of plume, lays real eggs. These eggs may be preserved in a dry place for the space of whole months, like the *seed* of silk-worms; and if afterwards sown in water, there will be produced from them as many polypus's. The bulb-polypus may be depicted by the epithet of *bulbiparous*. But how shall we describe the multiplication of other *cluster*-polypus's, that of the *net*-polypus's, and of the millipes? Lastly, the *spider-fly* presents us with another method of multiplying, in which there is nothing that is common with any of those above-mentioned, and which is attempted to be expressed by the term *nymphiparous*. How many other methods of propagating will there be discovered every day for which it will be necessary to create new terms!

8. One animal does not differ more from another than a worm from a nymph. And what renders this metamorphosis still more surprising is, that it seems to be performed instantaneously.

What then is the procedure of nature in this respect? She in other instances advances by degrees. An insensible developement brings all organized bodies to a state of perfection. Can this law, which is so universal, suffer any exception? A fact which I am going to relate will help us to penetrate this mystery.

Let us confine ourselves to *caterpillars*; they are sufficiently known to us, since the *silk-worm* is a real caterpillar. The catterpillar from time to time changes his ſkin, and that is common to him and moſt other inſects. Theſe *moultings* are termed *maladies* in the ſilk-worm, and they are ſo in effect. But it is very material to obſerve, that the ſkin which the caterpillar caſts off at each moulting is ſo complete, that it ſeems to be of itſelf a real caterpillar. There is found in it a head, eyes, a mouth, jaws, legs, armed with hooks, ſtigmata, and generally all the external parts proper to the inſect.

How is the caterpillar enabled to diveſt itſelf of ſo many organs, and cloath itſelf with new ones reſembling the firſt? Nothing can be more ſimple than this: new organs were lodged in the old ones, as in ſo many caſes or ſheaths. In changing its ſkin, the catterpillar had occaſion only to draw them away, and drew them away accordingly, becauſe the caſes proved too ſtrait.

This jointing is ſo real, that it may be perceived by the naked eye. It may even be demonſtrated by a very eaſy experiment. If on the approach of the *moulting*, we cut off the former legs of the caterpillar, ſhe will iſſue from her ſpoils without any legs at all. Thus this caterpillar, which we conſidered as a ſimple and ſingular being, was in ſome meaſure, a multiplied being, or compoſed of ſeveral ſimilar beings jointed into each other, and that ſucceſſively unfold themſelves.

9. Hence ariſes a very propable conjecture: may not the *chryſalis* be lodged under the laſt ſkin the caterpillar is to caſt off? May not this ſkin be a maſk that conceals it from our ſight?

A celebrated obſerver has, by a deciſive experiment, aſſured himſelf of the truth of this conjecture. He has removed the maſk, and has by this means diſcovered the *chryſalis* in a manner very eaſy to be diſtinguiſhed. He has ſeen the ſix legs of this chryſalis to grow out of the ſix former legs of the caterpillar, and all the other members of the latter to be wrapped together under different parts of the former.

The *metamorphoſes* of inſects, then, enter anew into the order of developements, and confirm it. The *chryſalis*, or rather the *butterfly*, for it is in the ſtricteſt ſenſe but a ſwaddled butterfly; the chryſalis, I ſay, pre-exiſted in the caterpillar. It does no more than unfold itſelf in it, and the caterpillar is a kind of machine prepared for performing afar off this developement. It is in ſome reſpects, to the chryſalis, what the egg is to the chick.

10. In truth an inſect that muſt *moult* five times before it is inveſted with the form of a *chryſalis*, is a compound of five organized bodies, incloſed within each other, and nouriſhed by common viſcera, placed in the center.

As the bud of a tree is to the inviſible buds it encloſes, ſo is the exterior part of the caterpillar newly hatched to the interior bodies it conceals in its boſom. Four of theſe bodies have the ſame eſſential ſtructure, and this ſtructure is that which is peculiar to the inſect in the ſtate of a *caterpillar*. The fifth body, which is very different, is that of the *chryſalis*. The reſpective ſtate of theſe bodies is in proportion to their diſtance from the center of the animal. Thoſe that are fartheſt off have more conſiſtence, or unfold themſelves ſooneſt.

When the exterior body has attained its full growth, the interior, which immediately follows, is is confiderably unfolded. It foon finds itfelf lodged in too narrow a compafs. It ftretches on all fides the fheaths that encompafs it. The veffels which convey the nourifhment to thefe coverings being broken or ftifled by this violent diftention, ceafe to act. The fkin wrinkles and dries up. At length it opens, and the infect appears cloathed with a new fkin and new organs.

A faft of a day or two precedes each *moulting*. It is probably occafioned by the violent ftate in which all the organs then are. Perhaps it might be alfo neceffary in order to promote the fuccefs of the operation, and prevent obftructions. Be this as it may, the infect is weak after every moulting. All its organs are yet affected by the ftate they were in under the covering they are juft difengaged from. The fcaly parts, as the head and legs are almoft entirely membranous, and are all imbued with a liquor that infinuates itfelf betwixt the two fkins, and facilitates their feparation. But this moifture evaporates by degrees: all the parts acquire a confiftence, and the infect is in a condition to act. The firft ufe that fome fpecies of caterpillars, which live only on leaves, make of their new teeth, is to devour greedily their fpoils: fometimes they will not even wait for doing it, till their jaws have received their full degree of ftrength. Can thefe fpoils be a proper aliment to renew and increafe their ftrength? Some caterpillars have likewife been feen to gnaw the fhells of their eggs after they have iffued from them, and even that of the eggs of fuch caterpillars as have not been hatched.

11. When we have once conceived that all the exterior parts of the fame kind are jointed into each other.

other, or laid one on another, the production of new organs has nothing embarrassing in it; and with regard to this, there is not any essential difference betwixt the five moultings that precede the transformation. Nothing more is requisite in all that, but a simple *developement.*

But it is not absolutely the same with respect to changes that happen in the viscera before, during and after the metamorphosis. Here the light that should guide us is almost extinguished, and we are constrained to grope in the dark.

It does not appear that the insect changes its viscera as it does its skin. Those which existed in the caterpillar, exist likewise in the chrysalis; but they are modified, and it is the nature of these modifications, and the manner by which they are performed, which elude our researches.

A little before the metamorphosis, the caterpillar rejects the membrane that lines the inside of the intestinal bag. This bowel which has hitherto digested gross food, must hereafter digest that which is extremely delicate. The blood that circulates in the caterpillar, from the hind part towards the head, circulates a contrary way after transformation. If this inversion be as real as observations indicate, what idea does it not give us of the changes the inside of the animal experiences? Those which the circulation of the blood in a new-born infant undergo, are in a manner nothing in comparison of them.

12. Whilst nature is labouring to change the viscera, and to give them a new life, she is employed at the same time in the developement of divers organs, which were useless to the insect while it lived under the form of a caterpillar, and which

which the new ſtate whereunto it is called renders neceſſary for it. The better to inſure the ſucceſs of her different operations, ſhe cauſes the inſect to fall into a deep ſleep, during which ſhe carries on her work at leiſure and by inſenſible degrees.

The little wounds which the rupture of ſeveral veſſels has occaſioned in divers parts of the inſide, conſolidate inſenſibly. Thoſe parts which had been put into a violent exerciſe, or whoſe forms and proportions had been modified to a certain degree, conform themſelves gradually to theſe changes. The liquors which are obliged to paſs through new channels, take that direction by little and little. Laſtly, the veſſels which were proper to the caterpillar, ſome of which occupied a conſiderable place within it, are effaced or converted into a liquid ſediment, which the butterfly rejects after having laid aſide the ſheath of the chryſalis.

13. When we conſider the metamorphoſes of inſects, we are ſurpriſed at the ſingularity of the means which the AUTHOR of nature has thought proper to make choice of, in order to bring the different ſpecies of animals to perfection.

Wherefore is the *butterfly* not bred a butterfly? Why does it paſs through the ſtate of a caterpillar, and that of a chryſalis? Why do not all the inſects that metamorphoſe themſelves undergo the ſame changes? Whence does it happen, that amongſt the ſpecies that aſſume the form of a *nymph*, ſome ſhed the ſkin of the *worm*, whilſt others retain it? How does it alſo come to paſs that among ſuch inſects as paſs through the ſtate of the *worm-ſkin* nymph, ſome take that form in the very belly of their mother?

Theſe queſtions, like all thoſe which may be ſtarted concerning *eſſences*, derive their ſolution from

from the general syſtem which is unknown tò us.

Without endeavouring then to penetrate into the cauſe of metamorphoſes, let us obſerve attentively the fact, and its immediate conſequences.

Let us conſider the variety which thoſe metamorphoſes diſperſe throughout nature. A ſingle individual unites within itſelf two or three different ſpecies. The ſame inſect ſucceſſively inhabits two or three worlds; and how great is the diverſity of its operations in theſe various abodes!

Let us alſo remark to what degree the relations which the fly or butterfly maintains with the beings that ſurround them, are multiplied by their metamorphoſes. Let us fix our attention on the *cone* of the ſilk-worm; and admire what a number of hands and machines this little ball ſets to work. What prodigious riches ſhould we have been deprived of, had the butter-fly of the ſilk-worm been originally produced in that form!

Inſects that undergo transformations, have not yet afforded us any ſpecies that multiplies by *ſlips* and *ſhoots*. This will not ſurprize us, when we reflect on the great compoſition of the bodies of theſe inſects. But let us not be too haſty in our judgment, nor conclude that the property of multiplying by ſlips and ſhoots is incompatible with metamorphoſes. Nature is too little known to us, to give us a right to form ſuch concluſions. Vine-fretters and polypus's have furniſhed us with good preſervatives againſt too general concluſions.

CHAP.

CHAP. X.

Parallel between Plants and Animals.

1. IN our refearches into the gradual progreffion of beings and organical œconomy, we had frequent occafion to compare vegetables and animals with each other. Let us here collect in one view thofe various marks of analogy which are fcattered hither and thither: let us reprefent them as in a picture, wherein by a nearer defcription of them, they will agreeably attract our attention. We will afterwards enquire if there be any character which effentially diftinguifhes the *vegetable* from the *animal*.

2. A *feed* is an organized body, which under various coverings, thicker or thinner, and more or lefs numerous, contains within it a plant in miniature. A whitifh fubftance, of a fpongy nature, fills the capacity of the feed. Small veffels which proceed from the germ, are in every part of this fubftance, dividing and fubdividing it. After being laid in the earth, moiftened and warmed to a certain degree, the feed begins to fhoot up. The moifture, which has penetrated its outward folds, diffolves the fpungy fubftance, and mixes with it. Of this mixture is formed a kind of milk, which being carried to the embryo by the little veffels, furnifhes it with a nourifhment adapted to its extreme delicacy. The *radicle* or *little root* begins by this means to unfold itfelf. It increafes in bulk and extent every day. In a fhort time it becomes fenfible

sensible of too close a confinement: it makes an effort to come forth. A small orifice, made in the exterior surface of the seed, facilitates its egress. The root insensibly sinks into the earth, and derives from thence more substantial and copious nourishment. The small *stalk*, which till this time lay hid under the coverings of the seed, now begins to shew itself. The teguments unfold themselves in order to admit a free passage for it. Strengthened by an accession of fresh juices, it pierces through the earth, and advances into the air.

3. An *egg* is an organized body, which under divers teguments, of various strength and number, incloses an animal in miniature. A fluid matter of a glutinous nature, fills the inside of the egg. A number of infinitely small vessels spread themselves out in this matter, and are connected with the germ by different branches. Being warmed in a sufficient degree, either by nature, or art, the inside of the egg begins to receive life. By means of a gentle heat, the matter surrounding the germ insinuates itself into the small ramifications, from whence it passes into the heart, whose motion it augments. Thus the animal becomes a living creature. It increases in size and strength every day, by receiving fresh supplies of more nourishing and perfect juices. After these juices are exhausted, the animal has acquired all the growth it was capable of in the egg. It finds the apartment assigned it to be too narrow. It endeavours to set itself at liberty. Nature has provided it with an easy method of effecting this, either by arming it with instruments proper for piercing or

or tearing the coverings which incloſe it, or by giving to the egg ſuch a ſtructure as favours its efforts. The animal is produced, and enjoys a new life.

4. The ſeed then is to the plant what the egg is, to the animal. But the plant is not only *oviparous* but likewiſe *viviparous*; and the *fœtus* is the ſame with reſpect to the *animal*, as the *bud* is to the *vegetable*.

Being concealed under the rind, the bud there receives its firſt growth. It is minutely iñcloſed in membranous teguments, analogous to thoſe of the ſeed. It adheres to the bark by ſmall fibres, which tranſmit a nouriſhment to it, adapted to its ſtate. When it has arrived to a certain bulk, it penetrates the rind in order to come forth. At its firſt appearance, it bears the infolding coverings along with it, from which it is ſoon releaſed. However, being as yet too feeble to ſubſiſt without the aliment provided by the mother, it continues to cleave to her; and cannot for a long time be ſeparated, without endangering it.

Being lodged in the matrix, the *fœtus* there receives its firſt growth. It is there contained at firſt in miniature, in the membranous incloſures reſembling thoſe of the egg It ſhoots forth ſmall veſſels in the matrix, which convey thither the nouriſhment neceſſary to promote its growth. When it has arrived to a certain ſize, it burſts theſe incloſures, and comes into the world. Sometimes theſe incloſures accompany it at its iſſuing forth. After it is produced, the little animal is not always able to provide for itſelf without the aſſiſtance of the dam. She muſt ſtill furniſh it with

with ſuſtenance, which it cannot diſpenſe with the want of, for a certain time without danger.

5. The plant is nouriſhed by the *incorporation* of ſubſtances received from without: theſe matters are very heterogeneous, Being pumped by the *pores* of the *roots*, or by thoſe of the *leaves*, they are conveyed into the *utriculi*, where they ferment and digeſt. They paſs into the *ligneous* fibres, which tranſmit them to the *proper vaſes*, where they appear under the form of a juice, which is more or leſs coloured. The ramifications of the proper vaſes afterwards diſtribute them into all the parts, to which they are united by new filtrations.

Tubes made of a ſilvered blade, which are elaſtic, and turned ſpirally like a ſpring, accompany the veſſels which contain the ſap in their courſe. Being appointed for the purpoſe of reſpiration, theſe tubes introduce a freſh elaſtic air into the plant, which prepares and ſubtilizes the ſap, and probably colours it, beſides contributing to its motion: the ſuperfluous matter, or that part which is not ſo proper to be mixed with the plant, is conveyed to the ſurface of the leaves, whence it evaporates by an inſenſible but very copious *tranſpiration*. *Globules*, *veſicles*, or other *excretory organs*, which are diſtributed among the young ſhoots or leaves, procure an evacuation of the groſſer matter, and ſuch as is of a ſtronger conſiſtence.

The *animal* is nouriſhed by the *incorporation* of matter which proceeds from without. This matter is very heterogeneous. Being received by

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the *mouth*, it is conveyed into the *ſtomach* and inteſtines, where it undergoes different preparations: it paſſes into the *lacteal veins*, and their dependencies, or into other like veſſels, whereby it is tranſmitted into the blood-veſſels, where it appears under the form of a fluid more or leſs coloured, or flowing. The ramifications of the blood-veſſels afterwards diſperſe it into all parts, with which it incorporates itſelf by new preparations.

Pipes compoſed of cartilaginous rings, or of a ſilvered and elaſtic blade, turned ſpiral-wiſe, communicate with the blood-veſſels, or follow them in their courſe. As they are appropriated to *reſpiration*, they introduce into the animal a freſh and elaſtic air, which prepares attenuates, and probably colours the blood, contributing likewiſe to its motion. The ſuperfluous matter, or ſuch part of it as is improper to be united with the animal, is carried to the ſurface of the *ſkin*. from whence it evaporates by an inſenſible but very copious *tranſpiration*. *Glands*, or other *emunctory organs*, placed in different parts of the body, procure the evacuation of the groſſer matter.

6. The *plant grows* by *unfolding*, or the gradual extenſion of its parts in length and width. This extenſion is followed by a certain degree of hardneſs contracted by the fibres. It diminiſhes as the hardneſs increaſes. It intirely ceaſes when the fibres are ſo far hardened as not to yield to the *force* which tends to enlarge their ſurface.

The plants which become hardened the lateſt, are thoſe which are the longeſt time in growing. *Herbs* grow and harden faſter than *trees*. Some of them ceaſe to grow at the end of a few weeks, or even a few days. Among the laſt, ſome continue to grow for a great number of years, and even for ages.

We observe analogous differences between individuals of the same species. Some harden sooner, grow in a less degree, or continue smaller; others harden later, and become larger.

The bud has nothing *ligneous* or woody in it. Being *herbaceous* in every part of its substance, it becomes ligneous by degrees. Its stalk is formed of a prodigious number of concentric blades one in another, which are disposed according to its length, and compose different bundles of fibres, which are themselves formed of a prodigious number of lesser fibres.

At the center of the stalk is placed the *pith*; and the spaces which are left between the blades, are likewise filled with a pithy substance.

From the thickness of the blades results its growth in width; from the lengthening of the blades its growth in length proceeds. All the blades grow and harden one after another. Every blade grows and hardens alike successively throughout its whole length. That part of every blade which grows and hardens first of all, is that which composes the base of the stalk. The blade which grows and hardens first, is the innermost, or that which immediately encompasses the pith. This blade is again covered with another, which, being more ductile extends itself the more. A third blade incloses this last, which as it hardens still later, is a longer time in its growth The case is the same with regard to a fourth fifth, or sixth. All these thus diminishing in thickness, and inclining towards the axis of the stalk as they approach its upper extremity, form so many little cones ingrafted into each other, from whence proceeds the conic figure of the stalk and branches.

From the aſſemblage of little cones which become hardened during the firſt year, is formed a cone of a woody nature, which determines the growth of that year. This cone is incloſed in another herbaceous cone, which is only the rind, and which the following year will produce a ſecond ligneous cone, &c. When the wood is once formed, it does not extend itſelf any farther. So that in *cicatrices*, *grafts*, and different kinds of tumours, the rind is the only part that is employed. By ſtretching, thickening, or ſwelling itſelf, the rind inſenſibly forms a *roll*, and produces excreſcences which are more or leſs conſiderable, in proportion to the eaſe with which it is diſtended, or according to the quantity of juices it receives.

7. The *animal* grows by *expanſion*, or by the gradual extenſion of its parts in every ſenſe. To this extenſion there ſucceeds a hardneſs in the fibres. The extenſion diminiſhes as the hardneſs increaſes. It ceaſes when the hardneſs has arrived to ſuch a pitch, as not to admit of the fibres giving way to the force which contributes to enlarge their coats.

Thoſe animals, in which this hardneſs is formed lateſt, are longeſt in their growth. *Inſects* grow and harden in a much leſs time than *great animals*. Some of them ceaſe growing at the end of ſome weeks, and ſometimes in a few days. Of the latter ſome continue growing for a great number of years, and even ſome ages.

One may obſerve analogous differences in the growth of individuals of the ſame ſpecies: ſome of which, that harden later than others, acquire a greater bulk.

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The *fœtus*, in its original ſtate, contains nothing of a bony nature. As it is *membranous* throughout, it only becomes *bony* by degrees. The bones are compoſed of a prodigious number of blades, folded in each other: lying, according to the length of the bone, and forming various collections of *fibres*, which are themſelves compoſed of the re-union of a great number of *little fibres*.

In the centre of the bone is placed the *marrow*. The ſpaces left between the blades are filled with a *medullary ſubſtance*.

From the thickening of the blades the growth of the bone procedes. From the lengthening of them, their extending in length. All theſe blades grow and harden after one another. Each blade grows and becomes hard in a like ſucceſſive manner throughout its whole length. That part of the blade which grows and hardens firſt, compoſes the body of the bone. Which immediately incloſes the marrow. This blade is again covered with a ſecond, which being more ductile ſtretches itſelf in a greater degree. A third blade again infolds this, which as it hardens later than the others, is a longer time in its growth. It is the ſame with reſpect to a fourth, fifth, or ſixth. As they all thus diminiſh in thickneſs, and detach themſelves from the axis of the bone, the nearer they approach to its extremities, they form ſo many little columns infolded within each other, which encreaſe in diameter at their extremities. From hence we deduce the figure peculiar to *long bones*.

The growth of the bone during the firſt year, is attributed to the number of blades which become hardened in that year. This bone is covered over again with a great number of *membranous* blades, that bear the name of *perioſteum*, which as they gradually extend and harden, conduce to the increaſe of the bone in every part of it. The bone when it is once formed, extends itſelf no farther.

Thus in *fractures*, *anchyloſes*, and the different ſpecies of excreſcences, whether natural or accidental, the *perioſteum* is the only part of the bone that labours. By ſtretching, thickening, and ſwelling itſelf, the *perioſteum* reſtores the bone inſenſibly, produces a caloſity, and forms greater or leſs tumours, in proportion to the facility wherewith it extends itſelf, or as it is more or leſs ſupplied with juices, or with ſuch as are more or leſs viſcous.

8. The duſt or fine powder of the *ſtamina*, is the principle which fertilizes the ſeed. The piſtil is the place where this fecundation is performed.

Being contained in certain *veſicles*, the *fecundating duſt* is diſcovered in them by a microſcope, under the appearance of a groupe of minute regular bodies, for the moſt part of a ſpherical or eliptic form, which being moiſtened, open themſelves, and emit a thin vapour, in which there floats a great number of exceeding ſmall ſeeds, which ſeem to move on all ſides. The duſt itſelf, when put into a drop of water, moves ſeveral ways with great rapidity.

The *piſtil* is compoſed of three principal parts; the *baſe*, the *cups*, and the *top*. The *baſe* contains one or more cavities, where the grain is lodged. The *cups* are long tunnels, whoſe baſe or aperture is turned towards the *top*. This is generally furniſhed with ſeveral *nipples*, each of which is *perforated*,

ted, having their diameter correſponding with that of a ſmall grain of the duſt.

Being in the lower part of the cup, the minute grains are preſſed in them more and more by the ſtraitneſs of theſe pipes. They are therein moiſtened with a juice that lines their ſides. They open themſelves, and eject the *ſeminal vapour*, which penetrates to the *ſeed*, and promotes ſecundation.

Several ſpecies of plants have two ſorts of individuals; *viz.* 1. Such individuals as only bear *ſtamina*, and theſe are males; and two individuals that have only the *piſtil*, which are females.

In a great number of ſpecies, every individual is an *hermaphrodite*, which unites both *ſexes*, the *ſtamina* and the *piſtil*. Sometimes this union happens in the ſame flower; then the *ſtamina* ſurround the *piſtil*. At other times it is only effected on the ſame *branch*; ſo that the *ſtamina* are placed on one part, and the piſtil on another.

9. The *ſeminal liquor* is the principal of *fecundation* in the *egg*. The *matrix* or ovaries are the places where it is performed.

Being incloſed in the *ſeminal veſſels*, the fecundating liquor appears in them, through a microcope, like a maſs of ſmall regular bodies, of different lengths which ſeem to ſeparate themſelves into a great number of extremely minute grains, moving different ways. Sometimes theſe corpuſcles reſemble caſes with ſprings, which when moiſtened, open themſelves, and dart forth a limpid matter abounding with a great number of very ſmall grains.

The *matrix* consists of three principal parts, or dependencies; the *fundus* or bottom, the fallopian tubes and the ovaries. The *fundus* contains one or more *cavities*, in which the *embryos* receive nourishment, and expand themselves: it has an *orifice* in the fore-part. The fallopian tubes are a kind of long funnels, whose aperture is directed towards the *ovaries*, where it ends. The *ovaries* are a mass of *vesicles* that are real *eggs*

When the most subtle part of the seminal liquor has arrived through the fallopian tubes to the ovaries, it there fecundates one or more eggs. These afterwards descend by these tubes into the matrix, where they are fixed and unfold themselves. In *oviparous* females the eggs are contained in a kind of bowel, wherein they receive their growth: the seminal liquor makes them fruitful.

Most animals consist of two sorts of individuals; *male* and *female*. But there are other species, of which every individual is an *hermaphrodite*, which unites the two, although it cannot fecundate itself. In some species, where a distinction of sexes is observed, there is no coupling, properly so called; the *male* only communicates his liquor to the eggs which the *female* has deposited. Finally, some species are propagated without any apparent or external fecundation.

10. A plant does not only *multiply* by *seeds*, and buds; it is likewise propagated by *suckers* and *sprigs*. It may also be multiplied by *slips*, and by *engrafting*.

A tree

A tree ſends forth ſmall buds from various parts of its ſurface. Theſe buds increaſe in bulk; they open and diſcloſe the *ſhoot*, which extends itſelf every day. While it is expanding itſelf other ſtill ſmaller ſprigs ſhoot from it. Theſe in their turn are ſucceeded by leſſer ones; all of which are ſo many trees in miniature; and the nouriſhment received by one of theſe ſprigs is communicated to the whole plant.

When it has attained to a certain ſize, and is ſeparated from the trunk either by nature or otherwiſe, theſe ſhoots ſuſtain themſelves, and become ſo many diſtinct trees. Being cut into pieces according to their width, or even their length, theſe ſhoots will grow again of themſelves, and will become as many trees as they were made ſlips of. The leaves themſelves when ſeparated from their ſhoots, may afford ſo many complete plants. Being faſtened cloſely to each other, or *inſerted* in one another, ſeveral of theſe ſhoots, whether taken from the ſame or from different individuals, will unite together in ſo intimate a manner, that they will receive reciprocal nouriſhment, and form one individual whole.

The animal is not only *propagated* by *eggs* and living young, but likewiſe by ſhoots. It may alſo be multiplied by *ſlips* and *ingraftings*. A polypus ſends forth little *buds* from different parts of his body. Theſe buds grow big and lengthen inſenſibly. Every one of them is a young ſhoot. While it is unfolding itſelf, there ſprings from it other ſmaller ſhoots. Theſe in their turn produce ſmaller ſtill. All theſe ſhoots are ſo many little *polypuſes*, and the nouriſhment one of these *polypuſes* receives, is communicated to their whole number. When they have arrived to a certain ſize, they ſeparate themſelves from the trunk, and become ſo many individuals.

Being cut into little bits, either tranſverſely or length-wiſe, the polypuſes grow up again from the ruins, and become as many complete ones as they were pieces. The very ſkin, or even the leaſt fragment of them, is capable of affording one or ſeveral *polypuſes*.

11. The *generation* of *vegetables* is not conſtantly regular. The laws by which they operate are ſometimes infringed. From them ariſe various ſpecies of monſters. Sometimes there are compounded leaves, whoſe ſmaller ones are more or leſs numerous, or more irregularly ſhaped, or diſtributed with leſs ſymmetry than uſual. Sometimes there are flowers which have neither *ſtamina* nor *piſtil*, and whoſe *petals* being greatly multiplied, ſeem to have abſorbed theſe eſſential parts. Sometimes two fruits cleave together by a natural *graft*, or are incloſed in each other. Sometimes there are *flowers* or *fruits* whoſe form differs widely from that which is peculiar to the ſpecies. Laſtly, There are productions which do not properly belong to any particular ſpecies, becauſe they derive their original from ſeeds that have been fecundated by *duſt* of a different ſpecies.

The *generation* of *animals* is not conſtantly *regular*: the laws by which it is governed are ſometimes diſturbed; whence are produced the different ſpecies of *monſters*. Sometimes there are *hands* and *feet*, whoſe *fingers* or *toes* are fewer or more

more in number, or formed in an irregular manner, or otherwise disposed than usual. Sometimes there are *fœtuses*, in which the *parts* of *generation* are obliterated. Sometimes there are two eggs or two *fœtuses* that cleave to each other by a natural cohesion, or that are contained in one another. Sometimes there are *eggs* or *fœtuses* whose form is greatly different from that which is peculiar to the species. Lastly, there are productions that partake of two species, because they are produced from such females as are fecundated by males of different species.

12. The laws respecting the nutrition and growth of vegetables are liable to greater disorders, than those of generation. From hence are derived the different kinds of maladies the *plant* is subject to. Some of these *maladies* only attack the leaves, and produce on them *spots* of different colours, *wrinkles*, *pustules*, *scabs*. Others attack the principal *viscera*, and occasion *choakings*, *obstructions*, *stagnations*, *tumors*, *cancers*, *effusion*. Others take their seat in the *flower* or *fruit*. Others affect the *ligneous* bodies, which they cause to moulder away, whilst the bark remains whole. Others come from little plants or divers insects, which being on the outside or inside of vegetables, convert their nourishment to their own advantage, or change the organization of it. Others derive their origin from a change of climate, aliment, or culture.

The laws of the nutrition and the growth of animals are more frequently disturbed than those of generation. From hence proceed the various species of *disorders* to which an *animal* is exposed. Among these maladies, there are some which attack only the *skin*, and produce *spots* of various colours, *wrinkles*, *pustules*, *pimples*. Others attack the principal bowels, and occasion *oppressions*, *obstructions*, *stagnations*, *tumors*, *abscesses*, *overflowings*. Others are seated in the *organs of generation*. Others seize the bones, and beget *rottenness* in them, whilst the *periosteum* continues sound. Others have their source from different insects, which, being lodged either without or within the animals, divert the nourishment of them to their own benefit, or alter the constitution of them. Others are caused by the change of climate, nourishment, or breeding.

13. Finally, the *plant* after having escaped a variety of maladies which threatened its life, cannot elude the effects of *old age*, that creeps into it, nor the stroke of *death*, the inevitable consequence of it. Being hardened by time, the vessels lose their exercise, and are stuffed up. The liquors contained in them no longer move with the same facility, nor continue to be filtred and pumped out with the same precision. They stagnate and corrupt; and this corruption being soon communicated to the vessels that inclose them, the vital functions cease, the plant dies and crumbles into dust.

Lastly, the animal, after having been preserved from those diseases which conspired against him, cannot escape *old age*, nor death that follows in his train.

When the vessels are grown hard through time they lose their action, and are stopped up. The liquors do not circulate in them with the same degree of quickness, and they are filtred and pumped

pumped up but in a very imperfect manner. They stand still and are altered, and this alteration soon communicating itself to the vessels that contain them, circulation ceases, the animal dies, and is reduced to dust.

14. We have carried the parallel between plants and animals from their birth to their death. The parts of which they consist very evidently establish the great analogy there is betwixt these two classes of organized bodies.

But there are other sources of comparisons, we have either avoided to dwell upon, that we might not render our description confused, or have only slightly touched upon; under certain points of view. Such are those presented to us by *place, number, fecundity, form, structure, circulation of liquors, loco-motive faculty, feeling, and nutrition.*

We will take a transient survey of these sources, and without endeavouring to exhaust them, content ourselves with barely pointing out their most remarkable and characteristical contents.

Vegetables and animals reside in the same dwelling-place. Being appointed to people and adorn our globe, they are dispersed over its whole surface, and are placed near each other, in order to enable them to afford a reciprocal assistance. Like two great trees growing in the same soil, the animal and vegetable kingdoms intwine their branches together, and extend their boughs and roots to the extremity of the world.

The outside and inside of the earth, mountains and vallies, barren and fertile places, countries undiscovered

diſcovered and hid in dark obſcurity, the regions of the north and ſouth, rivulets, rivers, ponds, lakes, and ſeas, have their vegetables and animals.

Many ſpecies of plants and animals ſeem to thrive alike in different climates. Other ſpecies are *amphibious*, and live as well out of the water as in it. The *bulruſh* and *frog* flouriſh in meadows, and at the bottom of ponds. Others are *paraſites*, and are nouriſhed by the juices they extract from different ſpecies. Such are the *miſletoe* and the *louſe*.

Laſtly, Some *pariſite* ſpecies ſupply their neceſſities, in their turn, from other paraſites. The *miſſeltoe* has his liverworts, and certain *lice* have their *lice*.

15. There are upwards of twenty thouſand ſpecies of plants known to us. and new diſcoveries of them made every day. A microſcopical botany has extended the dominions of the ancient. *Moſſes*, *muſhrooms*, *liverworts*, whoſe families are innumerable, now take place amongſt vegetables, and preſent the curious with flowers and ſeeds which before they were unacquainted with. The microſcope diſcovers plants to our view, where we never ſuſpected them. Free-ſtone is often covered with ſpots of different colours, commonly brown or blackiſh. Glaſs, notwithſtanding its fine poliſh, is not exempt from ſuch ſpots. We obſerve *hoarineſs* on almoſt all bodies. Theſe ſpots and this hoarineſs are found to be gardens, meadows, and foreſts in miniature, whoſe plants that are infinitely ſmall, afford us nevertheleſs ſome proſpect of their flowers and ſeeds.

But

But although vegetables are very numerous in their ſpecies, yet they are much leſs ſo than animals. Every ſpecies of plant has not only its particular ſpecies of animals, but there are many ſpecies of plants which nouriſh ſeveral ſpecies of animals. The oak alone finds nouriſhment for above 200 ſpecies of them. Some attack the *roots* of this tree, which they dig into, and produce therein various *tuberoſities*. Others fix themſelves in the *trunk*, where they make crooked furrows. Some inſinuate themſelves into the bark and *wood*; whilſt others penetrate the *interior* parts, whence they extract the juice. Some feed only on the *leaves*. Others *fold* or *roll* them up with a great deal of art. Some form them into *nuts*. Others find both lodging and nouriſhment in the *fruit*. Nay, gather but a flower by chance either a *daiſy*, *poppy*, or *roſe*, and you will obſerve on it a multitude of inſects.

In ſhort, where can we turn our eyes without beholding animals? Nature has ſtrewed them every where with a bountiful hand. They were her moſt excellent productions; ſhe has been liberal of them. She has incloſed animals within animals; ſhe has ordained one animal to be a world for others, which ſhould find therein nouriſhment in proportion to their wants. The air, vegetable and animal liquors, corrupt matter, dirt, dung, dry wood, ſhells, and even ſtones, are all animated, all ſwarm with inhabitants. What do I ſay? The ſea itſelf ſometimes appear to be one entire collection of animals. The light, which glitteringly reflects on it in the night-time, during hot weather, is produced by an infinite number of very minute glow-worms of a yellowiſh brown colour, and ſoft ſubſtance, not unlike caterpillars, every part of which, after being divided, and even putrified, ſhines

ſhines with the ſame brightneſs as when the worm was whole and living. A ſpecies of *ſea-fleas* are alſo luminous, and communicate their luſtre to the waters. There iſſues from within them a globular matter, which is likewiſe phoſphorous.

Herbs are more numerous in their ſpecies and individuals than *ſhrubs* and *trees*. *Inſects* are more numerous, in reſpect to their ſpecies and individuals, than *birds* and *quadrupeds*. There are more *ranunculuſes* than *roſe-buſhes*, and more blades of *graſs* than *oaks*. There are more *butterflies* than *fowls*, and more *vine-fretters* than *dogs*.

16. The magnificence of the creation ſhines in no part of it with greater luſtre, than in the prodigious fecundity of a great number of plants and animals. One ſingle individual may give birth to thouſands, or even millions of individuals like itſelf. Being formed agreeable to thoſe proportions which are only known to that ADORABLE WISDOM that has eſtabliſhed them, this great people was at firſt incloſed within the narrow compaſs of a rind or ovary. In this dark abode they receive their firſt life, begin to grow, and are diſpoſed to appear on the vaſt theatre of the viſible world.

If we conſider things in a general view, vegetables will be found to be more fruitful than animals. We ſhall be farther convinced of this, by comparing *trees* with quadrupeds.

Trees produce annually, ſometimes for many ages, and their productions are always very numerous. Large *quadrupeds*, as the *elephant*, the *mare*,

mare, the *hind*, the *cow*, &c. have ſeldom more than one at a time, rarely two, and the number they breed is always very moderate. Leſſer *quadrupeds*, ſuch as the *dog*, the *hare*, the *cat*, the *rat*, increaſe in a much greater degree; but their fecundity is but inconſiderable, when compared to that of *ligneous plants*. The elm produces yearly upwards of three hundred thouſand ſeeds; and this aſtoniſhing multiplication may continue above a century.

Fiſhes and *inſects* nearly reſemble vegetables in fecundity. A *tench* lays about ten thouſand eggs; a *carp*, twenty thouſand; and a *cod*, a million. An *inſect* which produces the *itch*, lays four or five thouſand eggs; a female *bee*, forty-five or fifty thouſand.

To this amazing fecundity is oppoſed that of the *wild poppy*, *muſtard*, *fern*. And we muſt not forget, that moſt vegetables are propagated different ways; whereas animals are for the moſt part propagated only by one.

A *tree* may be made to form as many trees as it has branches, boughs, and even leaves. Plants, which are principally deſigned to ſupply the neceſſities of animals, cannot be endued with too great a degree of fecundity.

17. There is hardly any ſight more intereſting, than that which the infinitely varied forms of plants and animals afford. If one compares the leſs perfect ſpecies with more perfect, or the ſpecies of the ſame claſs with each other, he is equally ſtruck with the diverſity of models, by which *nature* has

has performed her works in the vegetable and animal kingdoms. He passes with astonishment from the *swinebread* to the *sensitive* plant, from the *mushroom* to the *carnation*, from the *nightshade* to the *oak*, from the *ivy* to the *fir-tree*. He considers with surprize the prodigious multitude of *mushrooms* and *liverworts*, and can never enough admire the fecundity of nature in the production of these plants.

As he goes on to plants that are more elevated in the scale, he stops with pleasure to examine those plants that have *stalks*, from the grass which grows between the stones to that precious plant, whose *ear* furnishes us with the most wholesome food. He considers the various plants that *creep*, from the tender *bind-weed* to the *vine branch* which crowns our hills. He likewise takes a survey of those trees which bear fruit with *stones*, from the wild *plum-tree* to the *peach*, whose fruit does not excite our admiration more by the softness of its velvet covering and beautiful colour, than by the abundance and exquisite taste of the liquor it yields.

If from the vegetable, he transports himself into the animal kingdom, the prospect becomes still more interesting. He sees opposed to each other in the same portrait, the *polypus* and *sea dog*, the *day-fly* and *flying-fish*, the *dancing-bird* and *eagle*, the *grasshopper* and *flying-squirrel*, the *ant* and *stag*, the *cricket* and *rhinoceros*, the *wood-louse* and *crocodile*, the *scorpion* and the *ape*.

Another picture presents him with a view of the prodigious number of *butterflies* and *flies*; in considering which, he is astonished at NATURE's complaisance in thus diversifying these little animals

mals, so different from the great ones by their forms, and which have been treated as defective or imperfect beings.

Transferring next his survey to those species of animals immediately higher, he contemplates *shell-fish*, from that whose precious liquor dyes the garments of kings, to the *sailor* that rows with so much grace and skill on the inconstant wave. He observes the different species of fish, from the dangerous *cramp-fish* to the powerful *nerval*, and from the pretty *golden-fish* of China to the *dolphin*, that cleaves the billow with the swiftness of a dart.

He likewise takes a review of those *birds* that live on *herbs* or *seeds*, from the *linnet*, that delights us with his melody, to the *peacock* that pompously displays in our court-yards the gold and azure with which he is enriched. He also observes the birds of prey, from the fierce *merlin* to the *eagle*, whose strength and courage have raised him to the sovereignty over the birds. He next reviews the *quadrupeds*, from the light aud timorous *hare* to the *elephant*, whose enormous corpulency attracts every eye, and from the wily *fox* to that noble and generous quadruped which seems formed to have dominion over the animal creation.

Plants, though prodigiously various in their forms, yet are less so than animals. There are fewer gradations from the *truffle* to the *sensitive plant*, or from the *nightshade* to the *oak*, than there are from the *oyster* to the *ostrich*, or from the

the *sea-nettle* to the *oran-outang*. Plants, being essentially more simple than animals, have not given birth to so many combinations.

The forms of animals afford us a singularity which is extremely remarkable, and sufficient to distinguish them from vegetables; I mean those admirable metamorphoses which the same insects exhibit to us, which are sometimes so opposite, that it does not appear to be the same animal.

But may we not compare the bud in which a plant or flower is infolded, to the covering of a *chrysalis* which conceals the *butterfly* from our sight? And as the plant cannot produce seeds till the flower has issued from the bud, so neither can the butterfly propagate till it has cast off the sheath of the *chrysalis*.

18. It is not so easy to compare plants and animals in their *interior forms* or *structure*, as it is in their *exterior*. We may judge of the one by a single glance of the eye: we must bestow a particular attention, to judge of the other. We penetrate with greater difficulty, into the inside of a plant, than into that of an animal. The microscope, scalpel, and injections, which are so serviceable to us in the anatomy of animals, assist us very imperfectly in that of plants. It is likewise true, that this part of organical œconomy has been less studied.

But how imperfect soever the anatomy of plants may be, we are able to discover some of their principal vessels. These may be ranged under two general classes; the *longitudinal* that extend the

the whole length of the plant; and the *transverse* vessels, or such as are placed across it. The *sappy* vessels and *trachæan* belong to the first class; the *utriculi* or *insertions* to the second. The vessels containing the sap seem designed to convey the juice. The *utriculi*, or little bags, appear intended for digesting it.

Some plants seem to be intirely composed of *utriculi*: such are certain species of *roots* and *sea-plants*, whose texture is almost altogether vesicular. It is the same with those animals which seem to consist of stomach only, as the *polypus* and *tape-worm*.

One of the principal characters by which we may distinguish insects from large animals, is, that the former have no bone within them. What they have of a bony or scaly nature is placed on their outside for a support or defence to the more delicate parts underneath, or to sustain the body with greater advantage. Thus we see that in almost all insects, *properly so called*, the head, corslet, legs, rings, &c. are either wholly, or for the most part doubly covered with scales.

Herbs differ from *trees* as insects from large animals. They have no *ligneous body* in their center. What they have of a ligneous nature, appears on the outside, and serves to protect the weaker parts of the plant. Thus we find plants with tubes are strengthened by knots placed at regular distances; so that the lowermost knots which are designed for the base, are stronger and nearer each other than the upper ones. It is on the same account that the roots of many herbaceous plants, as well as the *calixes* of flowers, and the capsules or coverings of the seeds, are made almost ligneous.

Herbs

Herbs grow and become hard fooner than *trees*. *Infects* than great animals. Herbs and infects, being of a fofter confiftence than trees and large animals, extend themfelves with greater eafe, and fooner arrive at the period of their extenfion. Befides, the concentric beds of the bark of trees, and thofe of the *periofteum* of animals, being far more numerous than the relative beds of herbs and infects, muft needs require a longer time for their growth.

We may diftinguifh two kinds of parts in organized bodies; to wit, *fimilar* and *diffimilar*. The former are compofed of fibres of the fame kind; the latter, of fibres of various forts. The nerves, arteries, veins, lymphatic veffels are the *fimilar* parts of our bodies; the brain, heart, lungs, ftomach, the *diffimilar*. Plants are almoft entirely compofed of *fimilar* parts. The veffels containing the fap, the *trachæa*, and *utriculi*, are of this kind. Thefe different veffels are pretty uniformly difperfed throughout the whole body of the plant: they enter into the compofition of all its parts. They are to be met with in the root, ftalk, branches, leaves, flowers and fruits. The leaft fragment, the fmalleft leaf, is a reprefentation of the whole, an abridgement of the plant.

There are likewife animals which are nearly compofed of *fimilar* parts. Of this number are many fpecies of long worms, and fome *aquatic millipedes*, *nettles*, and *fea-ftars*, *polypufes*, *moths*, *earth-worms*. All thefe animals are formed in fuch a manner, that each part of them, even the fmalleft, correfponds in miniature to the whole in all its parts.

In

In the *long worms* I just mentioned, we observe very distinctly a stomach, an heart, and some very small vessels which seem dependent on the latter. There is likewise no room to doubt that there is beneath the stomach, a *medullary* string, like that observed in other species of worms and caterpillars. Their *viscera* are not distributed into certain regions of the body; they are universally dispersed throughout its whole length; so that we may truly affirm that these insects are all brain, all stomach, all heart. But this brain, stomach, and heart, appear extremely simple; the first is scarce any thing more than a nervous piece of net-work, the second a membranous bag, and the third a grand artery.

Polypuses, which are more simple in their structure, are only a kind of bowel, sown with an infinite number of small seeds, which are tinged with the colour of the aliment.

Tape-worms partake of the structure of polypuses, but seem to be more compounded. They are formed of a chain of flat, membranous, and whitish rings, jointed together like the divisions of a reed. Each ring has on its upper part, or on one of its sides, a more or less sensible eminence, in the center of which is a small round aperture. The middle of the ring is full of vessels of a purple or whitish colour, which perform a labour that attracts the attention of the observer. The rest of the ring is filled with an infinite number of small white seeds. Such is essentially the structure of the tape worm in its whole extent; there is no perfect variety or resemblance between all the rings

rings, the assemblage of which composes a kind of ribband or lace, which extends sometimes several hundred feet in length.

Earth-worms are, of all the insects I have mentioned, those whose inside seems to be the most compounded, chiefly because in them the two sexes are united : but the most essential organs of life are distributed in them likewise through the whole length of the animal.

Organized bodies, whose structure is so simple and uniform, that each part of them has in a small compass an organization resembling that of the whole in a greater extent, enjoy divers prerogatives that have been denied to organized bodies of a more complicated structure. The first of these are not destroyed when divided asunder. Their different portions continue to live, and the wounds which have been given to them easily consolidate. These parts vegetate, receive nourishment, produce new organs, and multiply. Such wonders as these the vegetables and insects we have lately treated of exhibit every day : wonders which we have not sufficiently admired in the former, and which perhaps we too much admire in the latter,

Large animals do not furnish us with the same *phænomena*. The consolidation of their wounds, and the re-union of their fractures, although oftentimes attended with circumstances which render them very remarkable, strike us but slightly when compared with what we observe analogous in polypuses, and other insects that multiply by slips. The motions we perceive in certain

certain parts of great animals, when separated from the body, or after the death of the animal, affect us only with a slender degree of surprize, when we consider the motions of different parts of worms, or those of some *millepedes*.

But may there not be some misconception in these different judgments? We judge of the effect produced, as considered in itself, and separate from the circumstances accompanying it; whereas we should judge of it with relation to the greater or less degree of composition whereof the body, in which this effect is produced, consists. There is as much, and indeed more to be admired in the consolidation of certain wounds, or in the re-union of certain fractures of our body, than there is in the consolidation of the wounds of polypuses, or in the re-union of parts which have been separated from them. A very simple machine is easily repaired; a machine that is extremely compounded, cannot be repaired with the same facility. When we reflect on the prodigious number of similar and dissimilar parts contained in the composition of the bodies of great animals, and particularly in that of the human body; when we attend to the strict connexion of all these parts, and to the degrees of composition in each of them, we cannot sufficiently wonder that the various accidents which happen to these bodies are not attended with greater consequences; we shall at the same time perceive the reason why they are not enabled to propagate like bodies whose organization is more simple.

But independently of the greater or less degree of the composition of parts necessary to life, as oon as these parts are found placed in different regions of a body, and are not dispersed throughout its whole length, such a body cannot be multiplied by slips. The AUTHOR OF NATURE, by denying, in his wisdom, this property to large animals, by confining the sources of life in them within a narrow circle, has secured them from harm by many advantages. Compare the result of the motions or actions of a sea-worm with that of the motions or actions of an ape, and you will soon perceive which of these animals has been most favoured.

Finally, organized bodies, to which a power has been granted of multiplying by a method which seems to tend to their destruction, are such as are exposed to the greatest dangers, and whose life is necessarily threatened every moment with a thousand various accidents.

19. Amongst the motions we observe in the animal machines, that of the circulation holds the first rank, either by its importance, or its nature, duration, and the number of organs by means whereof it is performed. There is in this motion an air of grandeur that seizes forcibly on the mind, and which, by making it sensible of the narrow limits of human understanding, penetrates it with the most profound respect, and fills it with the highest admiration of the INFINITE MIND which illustriously shines in the DIVINE AUTHOR of it.

In the center of the breast, between two spongy masses known by the name of lungs, is deposited a fleshy a fleſhy pyramid, whoſe baſe bears two ſmall funnels like ear-rings, which communicate with two cavities contained in the inſide of the pyramid, and which divide it according to its length into two chambers or *ventricles*, the *right* ventricle and the *left*. This pyramid is the *heart*, the main ſpring of the machine. It has two principal orders of *muſcular fibres*; ſome of which paſs obliquely from the baſe to the point, others cut the latter tranſverſely. From the exerciſe of theſe fibres two oppoſite motions reſult; one of *dilatation*, the other of *contraction*. The heart ſeems to execute theſe motions by turning on itſelf like a ſcrew. Its point moves towards or from the baſe, by riſing or falling obliquely.

Two great veſſels, *viz.* an artery and a vein, communicate with each ventricle. The artery,† which communicates with the right ventricle, conveys the blood to the lungs. The vein,‡ which communicates with the ſame ventricle, forms the principal trunk of the veins, and carries back the blood from all parts to the heart. The artery,* which goes into the left ventricle, is the chief trunk of the arteries, and that which conveys the blood to all parts. The vein,‖ which ends at the ſame ventricle, tranſmits to it the blood that has been conveyed from the lungs.

The principal trunks of veins and arteries, are divided into ſeveral branches at a ſmall diſtance from the heart. Some tend towards the upper extremities, others towards the inferior.

The arteries and veins decreaſe in diameter, and are ramified more or leſs according to their

 diſtance

† The pulmonary artery. ‡ The vena cava. * The grand artery, or the aorta. ‖ The pulmonary vein.

diſtance from their origin. There is no part to which theſe do not diſtribute one or more ramifications.

When they have arrived at the moſt remote parts, the arteries have an intercourſe with the veins.

The arteries are compoſed of ſeveral membranes, placed on each other. The veins have ſimilar membranes, but more ſlender, and weaker. The veins were not deſigned to exerciſe the ſame power as the arteries. Theſe latter muſt neceſſarily, like the heart, and for the ſame end, dilate and contract themſelves: they have therefore been provided with a very elaſtic membrane. The exerciſe of the veins ſhould not be violent.

At the root of the arteries, and in the inner part of the veins, are placed little ſluices or valves, which by ſinking and riſing again open and ſhut the canal. Theſe valves are depoſited in the veins, in a contrary ſenſe from that for which they are in the arteries. We ſhall preſently account for the cauſe of this difference.

20. After having been maſticated and diſſolved in the mouth and ſtomach, the aliment deſcends into the inteſtines, where it receives a new preparation by the mixture of two liquors, one of which is furniſhed by the liver, and is called the bile; and the other by a ſpecies of * gland ſituated under the ſtomach.

The aliment is thus converted into a kind of greyiſh pulp, which has received the name of *chyle.* Being ſhifted from place to place by the vermicular or *periſtaltic* motion of the inteſtines, and

* The pancreas and pancreatic juice.

and ſtrongly preſſed againſt their ſides at the inſtant of their contraction, the chyle penetrates into extreme ſmall veſſels, ‡ which open themſelves in the internal membrane of the inteſtinal canal. Theſe veſſels tranſmit the chyle to very ſmall glands which are covered with a kind of membrane ‖ ſituated in the midſt of the inteſtines, and round which they are in a manner rolled. After being filtred in theſe glands, the chyle is received by other veſſels, § which convey it into a concavity * placed along the ſpine, and which pours it into a vein ſituated under the left clavicle. There it enters into the blood, and loſes the name of *chyle*. From this vein the new blood paſſes into the upper branch of the principal trunk of veins, which carries it towards the heart. It paſſes into the right lobe, which opens at its approach, and by cloſing immediately, forces it into the right ventricle, which is dilated in order to receive it. The heart inſtantly contracts itſelf; the valves with which the ventricle is furniſhed, raiſing themſelves to oppoſe the reflux of the blood into the lobe, it is compelled to paſs the artery, which is appointed to carry it to the lungs. The valves, which are placed at the entrance of this artery, ſink down; the artery dilates, and the blood advances into the cavity. The valves riſe again, and prevent its return towards the heart. The artery contracting itſelf, the blood is impelled farther, and, by theſe alternate dilatations and contractions of the veſſel, it is conveyed to the lungs, where it runs through every part of them. The

‡ The primary lacteal veins. ‖ The meſentery and meſenteric glands. § The ſecondary lacteal veins. * The thoracic duct.

ramifications of the *trachæ*, * which are dispersed in the *viscera*, carry thither a fresh and elastic air, which, by acting on the lungs, dilates, winds them about, extends and opens them, and by that means facilitates the course of the blood into the smallest ramifications of the artery. Besides, being impregnated with this air, the blood becomes thereby attenuated, is cooled, and receives a more lively colour. After its arrival at the extremities of the artery, it passes into that of the *pulmonary* vein, which conducts it to the left ventricle of the heart. This latter, by contracting itself, pushes it into the *aorta*, † which by continually dividing and subdividing itself, distributes this balsamic liquor to all the parts, in order to promote their growth, or support, and occasion different *secretions*.

21. Such is the admirable mechanism of the circulation of the blood in men, and in those animals which we are best acquainted with. But how greatly does this imperfect sketch fall short of the reality! How incapable are these outlines of expressing the beauties of this noble subject! And who can account for the manner by which the strength of life is repaired and recruited? Who can conceive the cause of that perpetual motion of the heart, which continues without intermission for the space of seventy, eighty, or an hundred years, which has lasted for ages in the first race of men, and which remains almost as long in some species of animals? Have we discovered the exact part where the artery is changed into a vein? Have we disclosed the mystery of the secretion of those spirits, whose prodigious subtilty and activity give them

* The bronchia. † The principal trunk of arteries.

them a near resemblance to light? Can we even determine in what manner the grossest secretions are performed? Do we understand the true mechanism of muscular motion? Have we been able to find out the source of that great strength which often so far exceeds that of the heart? All these dependencies on circulation are yet unrevealed to us. The gloom of night still wraps these regions in dark obscurity, and you are earnestly desirous of chasing it away from before that sun which alone can dispel these shades. Will the dawn of that day ere long gild the horizon of the learned world? Or is the time of its breaking forth upon us yet afar off?

But if we are not able to discover the whole, we may at least see enough of it to excite our admiration; and the sketch which I have just drawn of the circulation, is sufficient to enable us to conceive the highest ideas of the SOVEREIGN MIND, which has appointed the manner, duration, and end of it.

Far less magnificent in its plans, less skilful in the execution of them, hydraulics offer to us but faint images of this miracle, in those machines by means of which water is raised above the mountains, in order to its being distributed into every quarter of a great city, and made to circulate and issue forth, under an hundred various forms, into those gardens which art and nature vie with each other in adorning and embellishing.

The works of the CREATOR must be compared with the works of the CREATOR. Ever like HIMSELF, HE has impressed on all HIS productions a character of noblenefs and excellence, which demonftrates the grandeur of their origin. From that immenfe mafs of water which encompaffes the great continents, there inceffantly arifes an ocean of vapours, which, being rarefied by the combined action of the fun and air, fpread themfelves in the upper region of the atmofphere, where they remain fufpended *in equilibrio*, being intermixed with the fluid in which they float, and gravitate with it. Collected afterwards into clouds more or lefs denfe, and borne on the wings of the winds, they fly acrofs the celeftial plains, which they adorn with their rich colours, and continually variegated forms. Fixed at length on the mountain tops, they pour upon them abundant rains, which being collected in the vaft refervoirs embofomed within them, furnifh, by a happy circulation, a fupply to fountains, rivers, lakes and feas. Like veins and arteries, the rivers flow meandering, and branching on the furface of the earth, they run through immenfe countries; water, fertilize, and unite them by a reciprocal commerce, and majeftically rolling their waves toward the fea, plunge themfelves into it, in order to be again exhaled in vapours, and re-enter afrefh into the channels of this magnificient circulation.

22. Does the fap *circulate* in plants as the blood circulates in animals? Is this new mark of analogy between thefe two claffes of organized bodies as real as it has appeared to be? Small bladders full of air which have been thought to be difcovered within the leaves, have convinced us that they were the *lungs* of the plant.

But there have not been difcovered in plants veffels analogous to veins and arteries. No organ has

has been ſeen in them capable of performing the functions of the heart. A tree which is planted a contrary way, with the roots a top and the branches in the ground, lives, grows, bears fruit; from its roots, branches ſhoot forth, from its branches, roots, The ſame is obſerved with reſpect to ſlips and layers. A young branch, or young fruit, after being grafted on a ſubject foreign to itſelf, incorporates with it, and derives from thence the ſame degree of growth it would have received from the plant whence it was detached. Experiments demonſtrate, that the motion of the ſap depends entirely on the alternatives of heat and cold, and the viciſſitudes of day and night. It is evident that the ſap riſes in the day from the roots to the leaves, and falls in the night from the leaves to the roots. In a word, the courſe of the ſap nearly reſembles that of the liquor contained in the tube of a thermometer. All is reduced to a ſimple counterpoiſe.

23. The nouriſhment of the more perfect animals requires to be more wrought than that of plants. Hence the neceſſity of the *circulation of the blood*. The preparations of the ſap do not require ſuch a punctual, regular, and conſtant motion; bare poiſings ſuffice. Large animals eat but at particular times: a preſſing ſenſation which induces them to take nouriſhment, does not continually act upon them. The different preparations their aliment ſhould undergo, would be diſturbed or interrupted, were a freſh ſupply to be received within them before the former was ſufficiently digeſted.

Plants, on the contrary, are in a ſtate of perpetual ſuction; they draw in nouriſhment continually, and in a very great quantity, in the day-time by their roots, in the night by their leaves. There is a plant which receives and tranſpires, in the ſpace of twenty-four hours, twenty times more than a man.

But if plants differ ſo much from large animals by circulation, on the other hand ſome ſpecies of animals ſeem nearly to reſemble plants by their want of this circulation. Not the leaſt appearance of this motion is to be perceived in the *polypus*, the *tape-worm*, the *pond-muſcle*, and divers other ſhell-fiſh.

24. One of the ancients defined a plant to be a rooted animal. He would undoubtedly have defined an animal to have been a wandering plant. The loco-motive faculty is one of thoſe characters which preſent themſelves firſt, when we compare the vegetable kingdom with the animal. We ſee plants that are conſtantly fixed to the earth. Being incapable of ſeeking their nouriſhment, it is ordained that this nouriſhment ſhall ſeek them. The greateſt part of animals on the contrary, are ſubjected to the care of providing their own ſubſiſtence. *Nature* has not always depoſited near them ſuch nouriſhment as was neceſſary for their ſupport. *She* has thought proper to oblige them to procure it for themſelves, often with much labour. And the different methods by which ſhe has inſtructed each ſpecies to obtain this end, much diverſify the ſcene of our world.

Whilſt the plowman opens the earth, to intruſts with it the ſeeds neceſſary to ſupport him, the mole and mole crickets are clearing for themſelves different routs, in the ſame time, to ſearch for the food allotted to them. The huntſman purſues his prey with

with an obstinate resolution: triumphing in his swiftness and strength. At other times preferring craft he becomes master of it by laying snares for it. The tyger rushes on the fawn sporting in the meadow. The cat watches motionless and silent, till the young mouse issues forth from its retreat, that she may dart upon it in a moment. Some species of animals, resembling mankind by their prudence, lay up provisions against a time of scarcity; build themselves magazines, in which are observed such just proportions, as to give us cause to doubt whether it was the workmanship of a brute, were we not convinced that this brute itself is the work of SOVEREIGN REASON.

25. How great is the distance in this respect from the beaver and bee to the gall or cochineal insect, the oyster, the sea-nettle, and several other kinds of insects and shell-fish? The gall-insect *, being confounded by his immobility and form with the tree on which he lives, contents himself with extracting its juice. Carried by the wave to the sea-shore, the oyster remains fixed there, and all its motions consist in opening and closing its shell. The sea-nettle, and all the different polypuses with *pipes*, being continually fixed to the same place, open and shut like a flower; extend and contract themselves like a sensitive plant; stretch out arms, by means of which they seize insects. This is their principal character, and the least equivocal character of their *animality*.

Thus it appears that the *loco-motive* faculty is not more proper for distinguishing the ve-

 getable

* See chap. viii.

getable from the animal, than thofe other charac-ters which we have before treated of. In the mean time, what can be more diftinct in appear-ance than a plant is from an animal? Or what more eafy to characterife in the fight of the major part of mankind? But when once we are con-vinced that every thing in nature is fhadowed over, we are not furprized at the difficulties we meet with in our attempts to diftinguifh beings. We expect to fee the fpecies enter again into each other; and confine ourfelves to the fmalleft lati-tude, or to that which is attended with the leaft uncertainty. In this principle we will conclude the parallel: let us fee whether feeling, and the manner by which animals and vegetables are nou-rifhed, will furnifh us with any thing more cha-racteriftical.

26. If there be any faculty which feems pe-culiar to the animal, it is certainly that of *feeling*. Being united to an organized fubftance by ties which perhaps are known to God only, this foul compofes with this fubftance a *mixed* being, a be-ing which partakes of the nature of bodies, and of that of fpirits. As a portion of matter, it is a ma-chine which is admirable in its ftructure, and on which corporeal objects act mechanically. As a fpiritual fubftance, it is affected at the prefence of fpiritual objects in a manner which does not feem to have any relation with that by which mate-rial fubftances act on each other. From the ex-preffion of external objects on the machine, there refults a certain motion in the machine. From this motion there follows a certain fenfation in the foul, which is fucceeded by the re-action of the fpiritual fubftance on the corporeal; a re-action which

which manifests feeling from without, and which is the expression or *sign* of it.

The various sensations in the animal may be reduced to these two general classes, *pleasure* and *pain*, separated from each other by degrees which are frequently insensible, and issuing from the same origin. The expression of pleasure and pain is not alike in all animals; because the organs, by means whereof the soul manifests her sentiments, are not the same in all.

There are species in which feeling is manifested by a greater number of signs; more varied, more expressive. What expression for instance, is there in the air, the motions, and the various attitudes of an ape, an horse, a dog, a cat? There is not much less expression in birds than in quadrupeds. Fishes do not express themselves with the same clearness and energy; they form a dumb people, amongst whom the language by signs is little practised: but the extreme vivacity of their motions seems in part to compensate for their sterility of expression. Reptiles, shell-fish, and insects, which are still at a greater distance from us than fishes, express to us their feelings in a more obscure manner; but which, notwithstanding, we can conceive to a certain degree, and often acknowledge to be very expressive.

On the contrary, we do not discover in the plant any sign of feeling. All in that seems to be purely mechanical. Its life appears to be less a life than a simple duration. We cultivate a plant, or we destroy it, without experiencing any thing similar to what we meet with when we cherish an animal, or put it to death. We see the plant shoot

ſhoot forth, grow, flouriſh and bud, as we perceive the hand of a clock to have paſſed over the points of the dial.

Theſe conſiderations lead us to conſider *feeling* as a character proper for diſtinguiſhing the vegetable from the animal.

27. Since then the faculty of feeling furniſhes us but with a doubtful character for diſtinguiſhing the vegetable from the animal, which is that we ſhould have recourſe to with this view? I think we have exhauſted them all; we have at leaſt treated of them all in a curſory manner. But we have not examined them all under their various aſpects. There is one of them, which being conſidered in a certain point of view, may perhaps procure us what we have in vain ſearched for in the others.

We may now conſider the poſition of thoſe organs by which plants and animals receive their nouriſhment. Theſe organs in plants are the roots and leaves. Both of them are furniſhed with pores, by means of which they pump in the nutritious juice. Theſe pores terminate at ſmall veſſels, which tranſmit the juice into the inner part: or, rather, theſe pores are only the extremity of theſe veſſels.

Animals have organs which are entirely analogous to roots and leaves; I mean *lacteal veins*, or veſſels which anſwer the ſame purpoſe. Theſe veins open themſelves in the inteſtines, and pump the chyle into them, which they convey into the

channels

channels of circulation. An animal is then an organized body, which is nourished by roots placed *within him*. A plant is an organized body which receives its nourishment by means of roots placed *on its outside*.

Yet an animal which is nourished by pores distributed on its outside, renders this character ambiguous. The *tape-worm* seems such an animal. It forms in the intestines a great number of plaits: and sometimes intirely fills the capacity of this canal. Each of the rings that compose it, and whose length is rarely more than one or two lines, is pierced with a small round aperture, by which one may see the chyle issue, which the worm is full of, and which constitutes its principal nourishment. If this aperture is a kind of sucker, by the help of which the insect pumps the chyle that surrounds it, this method of nourishing itself varies but little from that of plants.

But without seeking very far for examples of animals that are nourished like plants, this is the case of all animals, whether oviparous or viviparous, whilst they are inclosed in the egg, or in the belly of their mother. The *umbilical* vessels may be considered in the *egg* or in the matrix, as roots which imbibe the nourishment. It is the same with respect to insects that multiply *by shoots*. Whilst the young one still adheres to its mother, it is nourished in a manner little different from that which is peculiar to branches. Animal grafts nearly resemble vegetable in this particular.

Lastly, The skin of the human body imbibes, like the leaves of plants, the vapours with which the air abounds: and although men draw in much less lefs nourifhment by this means than vegetables, it is neverthelefs true that their fkin and leaves have, in regard to this circumftance a great affinity to each other. Perhaps we may be able fome time or other to difcover animals which are nourifhed by their fkin only, as certain plants are by their leaves.

28. Do we then in vain feek for a peculiar character whereby we may diftinguifh the vegetable from the animal? I perceive a new property, which will perhaps furnifh us with what we feek for.

A *mufcular* fibre contracts of itfelf on the touch of all bodies, whether folid or liquid. This property is known by the name of *irritability*. It has nothing in it common to fenfibility. The parts which are moft fenfible are not *irritable*, and the parts which are moft irritable, are not *fenfible*. Neither ought we to confound irritability with *elafticity*. A dry fibre is very elaftic, and not at all irritable. Animals purely gelatinous are not elaftic, and are notwithftanding very irritable. In fhort, the fibres of old men, though much more elaftic than thofe of infants, are much lefs irritable.

We have feen that the heart is a real *mufcle*. If we extract it from the breaft, it will continue to move till it has loft its natural heat. The heart of a viper or tortoife beats ftrongly for the fpace of twenty or thirty hours after the death of the animal. Water or air, when introduced into the *ventricle*, are fufficient to reftore to the heart the motion it has loft.

The

The *periſtaltic* motion of the inteſtines is likewiſe owing to their irritability. But the following is what we ſhould not have gueſſed at. If they are plucked haſtily from the lower belly, and cut into pieces, all theſe pieces will crawl like worms, and contract themſelves on the ſlighteſt touch.

So that not only every muſcle, but alſo every fragment of a muſcle, and even every muſcular fibre, contract themſelves more or leſs on being touched by any body whatſoever, eſpecially if that body be of a ſtimulating nature. And as the fibre contracts ſo it likewiſe recovers of itſelf, and this alternate exerciſe laſts for a time proportionable to the degree of irritability.

It is evident, from all the experiments that the *vital* parts are the moſt irritable. The heart is the moſt irritable of all, and next to that, the inteſtines and diaphragm.

The nature of irritability is unknown: we only judge of it by its effects. It probably reſides in the elaſtic fluid which is interſperſed between the *lamellæ* of the fibre. The *nerves* are not irritable; but if a nerve be pricked, the muſcle at which it terminates will contract itſelf. The nerves may then give motion to the muſcles; but they do not communicate an irritability to them which they are not poſſeſſed of themſelves; they only put it into action, and thus they are the miniſters of the affections of the ſoul.

Irritability then ſeems to be what conſtitutes the *vital power* in the animal; and this property has not been perceived in the vegetable. Is it not then the *diſtinguiſhing* character we ſeek for?

CHAP.

CHAP. XI.

Of the Induſtry of Animals.

1. HITHERTO we have ſcarcely conſidered animals in any other light than with reſpect to organization, and the immediate and general conſequences of it. We will now contemplate their induſtry, which is ſtill more intereſting to us.

Some animals ſeem reducible to feeling only. Others have all our ſenſes, and riſe almoſt to underſtanding. The diſtance from the *polypus* to the *ape* appears enormous.

Imagination and memory are obſervable in divers ſpecies: imagination, in their dreams; memory, in the recollection of ſuch things as have affected them. Places, perſons, animate and inanimate objects are traced out in their brain, and they act agreeably to theſe repreſentations.

The degree of knowledge in each ſpecies anſwers to the place it occupies in the general plan. The ſphere of this knowledge extends to all caſes which the animal may naturally meet. And if the animal happens to be drawn from his natural circle, and nevertheleſs is not intirely removed out of it, we may conclude that this new ſituation has a relation to one of the caſes to which the ſphere of his knowledge extends.

The

The way whereby animals vary their proceedings as necessity requires, furnishes one of the strongest arguments against the opinion which transforms them into mere machines. The philosopher who attributes to them a soul, founds his judgment on the analogy of their organs with ours, and of their actions with several of ours. Those who make the soul material, forget that even feeling is incompatible with the properties of matter.

The greater the number of cases is to which the knowledge of an animal extends, the higher is this animal elevated in the scale.

The preservation of life, the propagation of the species, and the care of their young, are the three principal branches of the knowledge of animals; but all are not alike to be admired in these respects.

The *oyster* knows only how to open and close its shell.

The *spider* spreads a net for his prey: waits like an huntsman, till some insect falls into the snare: hardly has he touched it, before he darts upon it. Is he armed, or too nimble? He fastens the lines to him with wonderful skill, and thus disables it either from flying or defending itself.

Divers species of animals live from day to day, without taking any thought for the succeeding day. Others seem endued with a kind of foresight, construct magazines with abundance of art, which they fill with various kinds of provisions: such are the *bee* and the *beaver*.

Among animals that live by prey, some, like the *eagle* and the *lion*, attack with open force. Others, as the *hawk* and the *fox*, join craft to strength.

ſtrength. Some ſave their lives by flight; others by hiding themſelves under the earth or water; while others ſtill have recourſe to divers ſtratagems to facilitate their flight, and evade the purſuit of their enemy.

Thoſe philoſophers, who take a great deal of pains to define *inſtinct*, are not aware, that in order to do it, they ſhould ſpend ſome time in the head of an animal, without becoming the animal itſelf. To ſay in general, that inſtinct is the reſult of the impreſſion of certain objects on the machine, of the machine on the ſoul, and of the ſoul on the machine; is to ſubſtitute terms that are a little leſs obſcure, inſtead of a very obſcure term: but the idea does not iſſue from the thick darkneſs that covers it. We well know what is not inſtinct, but are utterly ignorant what it is. It is not underſtanding, or reaſon. The brute has neither our notions, nor our *mean* ideas; becauſe it has not our *ſigns*.

2. At the ſame time that NATURE has taught divers animals the method of attacking and purſuing their prey, ſhe has inſtructed them in that of ſelf-defence or eſcaping. If we were converſant in the books of nature, we ſhould there ſee, without doubt, that the profit always makes amends for the loſs. A regiſter of the births and deaths of ſome ſpecies, put this truth beyond all controverſy.

Thoſe ſpecies which multiply moſt, have the greateſt number of enemies. *Caterpillars* and *vine-fretters* are attacked as much within as without, by I know not how many inſects, that are always

bent

bent on deſtroying the individuals, without being able to effect the deſtruction of the ſpecies. Many ſpecies ſeek their living or retreat in the inner part of the earth, or in that of plants and animals. Others build themſelves neſts or ſhells with amazing art, where they paſs their time in weakneſs and inactivity.

Some that are more ſkilful, can, like us, make themſelves cloaths, and even procure matter for their nouriſhment. They ſtrip our cloths and furs of their hairs, and make a kind of ſtuff of it, wherewith they clothe themſelves. The form of their dreſs is very ſimple, but very commodious. It is a ſort of muff or caſe, which they can lengthen or widen as they find occaſion. They lengthen it by adding to each end new layers of ſilk and hair, and widen it as we do a glove, by cutting it in the middle according to the length of it, and by ingrafting a piece. You may imagine that I am ſpeaking of *houſe-moths*; *field-moths*, which clothe themſelves with leaves, ſurpaſs them in induſtry.

Several kinds of *fiſhes* and *birds* change, at a ſtated time, their dwelling-places. We have ſeen numerous ſhoals of *herrings* and *cod-fiſh*, and *flocks* of *geeſe*, *quails*, and *crows*, reſembling thick clouds, that ſometimes darken the air. By ſuch periodical emigrations the ſpecies are preſerved, and in their long pilgrimages Nature is their pilot and provider.

3. The *graſhopper*, *lizard*, *tortoiſe*, and *crocodile* furniſh examples of animals that ſcarce take any care of their eggs, and are almoſt wholly unmindful

ful of the young that are hatched from them. They lay them in the earth or ſand, and leave the ſun to communicate the warmth neceſſary for them. Shell-fiſh practiſe the ſame method: ſome ſpawn in the water; others between ſtones, or in the ſand.

The inſtinct of the different ſpecies conſiſts in depoſiting them in places where the young may find proper nouriſhment at their birth. The mothers commit no miſtake with reſpect to that. The *butterfly* of the *cabbage-caterpillar* never lays her eggs on meat, nor the *fleſh-fly* on the cabbage.

The gnat, that flutters in the air, was at firſt an inhabitant of the water. For this reaſon her eggs are always depoſited in the water. The maſs formed by them reſembles a little veſſel which the inſect ſets afloat. Each egg is in the form of a keel. All the keels are vertical, and are diſpoſed back to back. The gnat lays but one egg at a time. We cannot deviſe how ſhe can cauſe the firſt egg or keel to remain on the water. Her method is nevertheleſs very ſimple, but much more ingenious. She ſtretches out her long legs behind her, croſſes them, and by thus forming an angle of them, receives the firſt egg, and holds it at pleaſure. A ſecond egg is ſoon placed next the firſt; then a third, fourth, &c. The baſe of the pyramid thus widens by little and little, and at length is capable of ſuſtaining itſelf.

Some ſpecies glue their eggs with great ſymmetry and propriety round the branches or ſmall ſhoots of trees, like rings or circles. One would be apt to ſay, that ſome ſkilful hand had been diverting

diverting itſelf in fitting pearl bracelets on the ſprigs. A caterpillar, which, from the diſtribution of its colours, is called *livery*, transforms itſelf into a butterfly, that diſpoſes her eggs in this manner, and forms theſe pretty bracelets of them.

Other butterflies do ſtill more: they ſtrip themſelves of their hair, and make with it a kind of neſt for their eggs, where they lie ſoft and warm. Such in particular is the induſtrious workmanſhip of the butterfly, proceeding from that called of the *common* caterpillar, becauſe it is in fact moſt common in theſe countries.

4. Certain ſpecies are ſo attached to their eggs, that they carry them about with them every where. The *wolf* ſpider incloſes hers in a little ſilk purſe, which ſhe bears on her hind-part. Does any one deſtroy it, or take it from her? Her natural vivacity and agility abandon her: ſhe ſeems to fall into a kind of languor. Has ſhe the happineſs to recover the precious truſt? She inſtantly ſeizes it, carries it away, and betakes herſelf to flight. As ſoon as the little ſpiders are hatched, they collect and arrange themſelves ſkilfully on the back of their dam, who continues for ſome time to beſtow her attention on them, and to tranſport them with her wherever ſhe goes.

Another ſpider lodges her eggs in a little ſilk purſe, which ſhe wraps up in a leaf. She fixes herſelf on this purſe, and ſits on her eggs with amazing aſſiduity. Another, to conclude, incloſes her's in two or three little ſilk balls, which ſhe ſuſpends by threads; but has the precaution to hang before, at a ſmall diſtance, a little bunch of dry leaves, to conceal them from the inſpection of the curious.

5. Dive

5. Divers species of *solitary* flies are not less to be admired, as well for their foresight in amassing provisions for their little ones, as for the art displayed by them in the nests they prepare for their reception. The *mason* bee, so called because, like us, she understands the art of building, performs such works in masonry, as one would imagine must greatly surpass the strength of a fly. With sand, collected grain by grain, and glued together with a kind of cement much preferable to ours, she erects a house for her family; a very simple one indeed, but extremely solid and commodious. It is divided within into several chambers or cabins, on the back of each other, without any communication between them. One general foldage, a wall of inclosure, comprehends them all, and leaves no opening without. This wall must be broke before the apartments can be seen, and it is found to be as hard as a stone. These nests are very common on the fronts of houses: they there resemble little oval hillocks, of a different grey from that of the stone. The fly that is the architect of these buildings deposits an egg in each chamber, and shuts up in it at the same time a stock of wax or *paste*, which is the nourishment appropriated to her young.

Another fly, which may be called the *carpenter* * bee, because she works in wood, likewise builds apartments for her family, but in a different taste from that of the *mason*. Sometimes she distributes them into stages; sometimes disposes them in a row. Cielings or partitions, artfully made, separate all these stages or chambers, and

* The *wood-piercing* bee.

and there is an egg depofited in each of them, with the quantity of pafte neceffary for the young.

6. Thefe various kinds of work require in general lefs fkill and genius than labour and patience. There is a very different degree of art and fagacity difplayed in the neft conftructed by another fly with fingle pieces of leaves only. This neft is a real prodigy of induftry. When it is taken to pieces, and narrowly examined in all its parts, one cannot conceive how a fly fhould be able to cut them out, turn, and put them together with fo much propriety and exactnefs. When viewed on the outfide, this neft very much refembles a tooth-pick cafe. The infide is divided into feveral little cells, in the form of a thimble, fet in one another as thimbles are in a tradefman's fhop. Every thimble confifts of feveral pieces, which are feparately cut from one leaf, and whofe form, circumference, and proportions tally with the place each is intended to occupy. The fame method is ufed with refpect to the pieces that form the cafe or common cover. In a word, there is fo much exactnefs, fymmetry, uniformity, and fkill in this little mafter-piece, that we fhould not believe it to be the work of a fly, did we not know at what fchool fhe learnt the art of conftructing it. We may naturally conjecture that each thimble is a lodging for a little one; but we could not have imagined that the pafte which the mother provides for it is almoft liquid, and that the little cell, which is entirely compofed of fmall pieces of leaves, is notwithftanding a veffel fo well clofed up, that this pafte never fpills, even when the veffel is ftooped.

 7. Many

7. Many brutes act in concert with each other. A drove of oxen is grazing in a meadow: a wolf appears: they immediately form into a battalion, and present their horns to the enemy. This warlike disposition disconcerts him, and obliges him to retire.

In winter, hinds and young stags assemble in *herds*, in the more numerous companies as the season happens to prove severe. They warm each other with their breath. In the spring they separate, the hinds concealing themselves in order to bring forth. The young harts remain together, love to walk in company, and are only parted by necessity.

Sheep that are exposed to the sultry heat of the dog-days in an open plain, keep near each other, so that their heads touch; they hold them inclined towards the earth, and snuff up the fresh air which comes from beneath them.

Wild ducks, that are accustomed to change their climate, range themselves in their flight in the form of a wedge, or an inverted V, that they may cleave the air with the greater ease. The duck at the extreme point leads the flight, and cleaves the air first of all. After a certain time he is relieved by another, the second in his turn by a third, &c. In this manner each bears a share in the laborious part of this office.

8. Animals to whom the company of their own kind is useful, have been rendered fit for this commerce. And if the AUTHOR of Nature had man in view with respect to this particular, as we

we may without pride ſuppoſe, the means will be found to correſpond perfectly well with the end. In effect, how many embarraſſments and inconveniencies would have accompanied the divers ſervices we deduce from domeſtic animals, if individuals of the ſame ſpecies had not power to cohabit together!

The ſpirit of ſociety is not altogether limited to individuals of the ſame ſpecies, but extends likewiſe in a certain degree to thoſe of different ſpecies, and from thence man alſo derives ſome advantage. The cuſtom of ſeeing each other, of eating their meals in common, of repoſing under the ſame roof, confirms the natural diſpoſition of domeſtic animals to live in ſociety. The connections which reſult from it become ſo much the ſtronger, as they began earlier or nearer to their birth. Thus animals that are not appointed to live together, may notwithſtanding form a ſort of ſociety: the natural inclination each of them has to live with thoſe of a like kind, is ſuſceptible of modification or extenſion.

Every individual knows his like; thoſe of the ſame ſociety likewiſe know them. It is obſervable, that if ſtrange fowls are brought into a poultry-yard, thoſe of the place will perſecute them, till cohabitation has made them members of the ſociety.

The outſide of the body exhibits divers characters, by means of which individuals of the ſame ſociety may know each other, and diſtinguiſh ſtrange individuals. But among theſe phyſical characters, there may be ſome *mixed* ones, or ſuch as belong as much to the ſoul as the body, which the animals of the class we are treating of, are capable of seizing; such are the air, posture, gait. The individuals of that species which are not yet become familiar in their new habitation, seem fearful or embarrassed; this fear or embarrassment detects them, and excites or encourages others to attack them.

That kind of society in which domestic animals live, gives room for a remarkable observation; the young lamb distinguishes her mother from amongst 3 or 400 sheep, although there does not appear to be any sensible difference betwixt them.

9. Nothing is more wonderful than those legions of flying creatures, that at a stipulated time pass from one to other very remote countries. What instinct assembles them? What compass directs them? What chart points out their way? We presently conceive that the change of the season, and the want of suitable nourishment, advertise these different species of birds to shift their abode. But whence did they learn that they should meet with in other regions a climate and aliment proper for them? In order to be able to answer these questions, and all such as may be asked on this interesting subject, we should carefully examine every circumstance that attends the marches of these birds. The degree of cold or heat that accelerates or retards them, deserves to be particularly attended to; for there is no room to doubt that they are most of all influenced by this. There is perhaps a secret relation between the temperature which suits with certain species, and that which is necessary for the production of the food that nourishes them.

But we have not carried our inquiries deep enough

enough into theſe different ſpecies of birds and fiſhes of paſſage.

10. Among the ſocieties of brutes *improperly ſo called*, ſome depend on chance, or on the agency of men, if not altogether, at leaſt in part. It is not ſo with reſpect to ſocieties *properly ſo called*. They do not owe their origin to any human act, but ſolely to nature. The members that compoſe them are not only united by common neceſſities, and that for a ſhort time; but they are ſo by a much ſtronger tie, which ſubſiſts to the death of the animal, or at leaſt during a conſiderable part of its life; I mean, the natural preſervation of the individual, or that of its family. Both the one and the other are neceſſarily attached to the ſtate of ſociety. It is for this great end that theſe different ſpecies of ſocial animals have been inſtructed to labour in common on works ſo worthy of admiration.

Societies *properly ſo called* may be divided into two claſſes; the firſt comprehends thoſe *whoſe principal end is limited to the preſervation of individuals*; the ſecond, thoſe *whoſe ſcope is, the preſervation of individuals, and education of their young*.

Several ſpecies of caterpillars and ſome ſpecies of worms belong to the former of theſe two claſſes; ants, waſps, bees, beavers, to the ſecond.

The firſt claſs will have under it two principal ſorts; one of which will comprehend *temporary* ſocieties; the other, ſocieties *for life*.

11. A butterfly depoſits her eggs, about the middle of ſummer, on the leaf of a plum-tree;

the number of these eggs is three or four hundred. After some days, there issues from each of them a very small caterpillar. They are so far from dispersing themselves on the adjoining leaves, that they all continue together on that whereon they first received their being: the same spirit of society unites them. They apply themselves immediately in concert in the spinning of a web, which at first is very thin, but they afterwards make it stronger, by gradually adding new threads to it. This web is a real tent spread upon the leaf, under which the young caterpillars shelter themselves. As they increase in bulk, they extend their lodging by fresh layers of leaves and silk. The spaces contained between these layers are apartments, all of which communicate by doors made on purpose. In this nest they pass the winter, placed near each other, without motion, till the returning spring enlivens them, and invites them to brouze on the sprouting leaves. Lastly, towards the month of May, the society is dissolved; every caterpillar separates from his companion, and spends the remainder of his life in solitude. Being then become stronger, a state of society is no longer necessary for them.

12. The caterpillars, that live on the oak, and whose societies are much more numerous than those of the *common*, are very singular in their proceedings. They set out from their nest at sunset, and march in procession, under the conduct of a chief, whose motions they follow. The ranks are at first composed only of one caterpillar, afterwards of two, three, four, and sometimes more. The chief has nothing in him that may distinguish him from the rest, but by being the first, and that he

he is not conſtantly, becauſe every other caterpillar may in his turn occupy the ſame place. After having taken their repaſt on the leaves around them, they return to their neſt in the ſame order; and this continues during the whole life of the caterpillar. When they have arrived to their full growth, each forms for himſelf a cone, where it is transformed into a chryſalis, and afterwards aſſumes the form of a butterfly. Theſe metamorphoſes cauſe a new kind of life to ſucceed to the ſtate of ſociety, which is very different from the primitive one.

This is an example of ſocieties *for life*, whoſe principal end is the preſervation of individuals.

13. There are ſeveral kinds of caterpillars that are true republicans, and whoſe diſcipline, manners, and genius, diverſify them as much as thoſe of different people. Some of them, like ſavages, make themſelves hammocks, in which they take their meals, and even paſs their whole lives. Others live like the Arabs and Tartars, in tents, which they erect in the meadows; and when they have conſumed all the herbs that grew about them, they go away and pitch their camp elſewhere.

The neſts which the republican caterpillars make for themſelves are perfect retreats; they are ſcreened in them from the injuries of the air, and are all cloſely ſhut up in times of inaction or idleneſs. But they go out at certain hours to ſeek their nouriſhment. They feed on the leaves which ſurround them, which they conſume one after another. They often go to a great diſtance from their dwelling, and by different turnings. However, they can always find it again, when they have occaſion. Nature has provided them with a method for regaining their lodging, which anſwers exactly to that uſed by THESEUS for fetching ARIADNE out of the labyrinth. We pave our ways; our caterpillars line theirs with tapeſtry. They never walk but on ſilk carpets. All the paths that lead to their neſt are covered with ſilk threads. Theſe threads form tracks of a gloſſy white, which are at leaſt two or three lines in width. By purſuing theſe tracks in a row, they never loſe their way, how intricate ſoever the turnings and windings of their paſſage may be. By putting a finger on the track, we ſhould interſect the path, and throw the caterpillars into the greateſt perplexity. They ſtop on a ſudden at this place, and expreſs all the ſigns of fear and diſtruſt. Their march is ſuſpended, till ſome caterpillar, more bold than the reſt, croſſes over the ſpoiled path. The thread ſhe ſpreads in croſſing ſerves as a bridge for the next to paſs over. This in paſſing ſpreads another thread; a third another, and thus the way is ſoon repaired.

Yet there is a great difference between the method of the republican caterpillars, and that of Theſeus. They do not ſpread a carpet over their paths, to prevent their miſſing their way; but they do not miſs their way, becauſe they ſpread ſuch a carpet. They ſpin continually, becauſe they have always occaſion to evacuate the ſilky matter, which their nouriſhment produces again, and which is incloſed in their inteſtines. By ſatisfying this want, they are aſſured of being in the right path, without attending to it. The conſtruction of the neſt is likewiſe connected with this want. Its architecture is adapted to the form of of the animal, to the ſtructure and exerciſe of his organs, and to his particular circumſtances.

14. Ants ſeek their proviſions and aliment at a great diſtance from their abode. Various paths, which are often very winding and intricate, terminate at their neſt. The ants paſs over them in rows, without ever miſſing their way, any more than the republican caterpillars. Like the latter, they leave tracks wherever they paſs. Theſe are not diſcernible to the eye; they are much more ſenſible to the ſmell; and it is well known that ants have a very penetrating one. However, if we draw a finger ſeveral times backwards and forwards along the wall by which the ants paſs and repaſs up and down in rows, they will be ſtopped on a ſudden in their march, and it will afford ſome amuſement to obſerve the perplexity they are in. It will happen in the ſame manner with regard to the proceſſions of theſe ants, as has been before related concerning thoſe of the caterpillars.

15. The ſight of a bee-hive is certainly one of the fineſt that can offer itſelf to our eyes. There appears in it an aſtoniſhing air of grandeur. One can never be weary of contemplating theſe workſhops, where thouſands of labourers are conſtantly employed in different works. We are ſtruck in a particular manner with the geometrical exactneſs of their works; as we likewiſe are at the ſight of their magazines, which are repleniſhed with every thing neceſſary for the ſupport of the ſociety during the rigorous ſeaſon. We likewiſe ſtop with pleaſure to behold the young ones in their cradles, and to obſerve the tender care of their nurſing mothers towards them.

But what chiefly attracts the attention, is the queen: the slowness, I had almost said gravity, of her march, her stature, which is a more advantageous one than that of the other bees, and, above all, the various homage paid her by the rest. We can scarcely believe what our eyes are witnesses of, in the regard and assiduities of the neuters for this beloved queen. But our amazement is greatly heightened when we see these laborious, active insects entirely cease from their labour, and suffer themselves to perish, as soon as they are deprived of their sovereign.

By what secret engagement, by what law superior to that whereby each individual provides for its own preservation, are the bees attached to their queen in such a degree, as absolutely to neglect the care of their own lives, when they happen to be separated from her? This law seems to be nothing more than the grand principle of the preservation of the species: the neuters do not engender; but they know that the queen enjoys that faculty: they construct those cells, whose proportions we so much admire, for the reception of the eggs she is ready to lay. Nature has instructed them as much with regard to the young that is to be hatched from them, as she has the mothers of other animals in favour of their offspring.

16. Of all animals that live in society, none approach nearer to human understanding than beavers. We are at a loss to determine what is most worthy of admiration in their labours, whether the grandeur and solidity of the undertaking, or prodigious art, fine views, and general design so excellently

excellently displayed throughout every part of their execution. A society of beavers seem to be an academy of engineers, that proceed on rational plans, which they rectify or modify as they judge necessary, pursuing them with as much constancy as precision; are all animated by the same spirit, and unite their will and strength for the promoting one common end, which is always the general good of the society. In a word, we must be witnesses of their performances, before we can judge them capable of them. A traveller that is ignorant of them, and happens to meet with their habitations, will think he is among a nation of very industrious savages.

The mole or bank which they raise, is a work of immense labour, and it is inconceivable how brutes are able to project, begin, and complete it. Represent to yourself a river of fourscore or an hundred feet in width. Their first business is, to break the force of the current. The beavers then throw up a bank or causeway eighty or an hundred feet in length, by ten or twelve feet at its base. Nothing is more certain than this, nor less likely: and when we have repeatedly seen it, are still willing to renew our inspection of it, in order to enforce our belief.

The most considerable towns of the beavers, consist of twenty or twenty-five lodgments, though such are but rare. The most common have only ten or twelve. Each republic has its peculiar district, and admits of no accidental guests.

When any great inundations damage the edifices of the beavers, all the societies without exception unite together for making the necessary repairs. If hunters declare a cruel war against them, and entirely destroy their banks and cottages, they disperse themselves about the country, betake themselves to a solitary life, dig burrows or trenches under-ground, and never shew any marks of that industry we have been admiring.

17. Beavers seem to be formed with a view to confound our reasonings. Their associating themselves into great bodies, for working in concert on their immense works; their separating into little families, or particular societies, charged with the construction of the huts; the nature of these works, their extent, solidity, propriety, and approbation so conducive to one general end, comprehending such a number of subordinations; in a word, their almost perfect resemblance with works erected by men with the same intent; all concur to give the labour of the beavers an undoubted superiority over that of the bees. In fact, to fell trees chosen on purpose, to lop them, and cut off their projections, to make great cross pieces of timber of them, disposing them in their proper places; to cut smaller trees like stakes, plant several rows of these stakes in a river, and interlace them with branches of trees, in order to strengthen and connect them together; to make morter, and with it solidly to compact the inside of the pile; and to all this to add the form, proportions, and solidity of a great bank; to form sluices thereon, and open or shut them according to the water's elevation or abatement; to build behind the bank little houses one or more stories high, founded on an entire pile-work; to build them solidly without, and incrust or cement them within by a

layer

layer of plaister, applied with equal exactness and propriety; to cover the flooring with a verdant tapestry; to contrive lights and outlets in the walls for different purposes; to erect magazines, and supply them with provisions; to repair with diligence whatever breaches may happen to the public works, and re-unite themselves into one grand body for the effecting in common these reparations; are astonishing marks of industry, which seem to imply in the beavers a ray of that light, which raises man so far above the rest of the animal creation.

CHAP.

CHAP. XII.

Continuation of the Induſtry of Animals.

1. WE ſhall in the next place treat of the proceedings of *ſolitary* animals. If they do not affect that extraordinary air of reflection and prudence, that brightneſs of genius, and that appearance of policy and legiſlation which we admire in *ſociable* animals, they neverthleſs attract our regard, either by their ſimplicity and ſingularity, or their diverſity and appropriation to one common end, for the attaining of which they uſe the ingenious and natural means. After having contemplated the government, manners, and labours of a *republican* community, we may ſtill find ſome pleaſure in conſidering the life and occupations of a *ſolitary* one, thus paſſing from the monuments of *Rome* to the cottage of a *Robinſon*. Thoſe works that are performed by the ſociable animals, and which aſtoniſh us as much by their ſize, as by the beauty of their diſpoſition, reſult from the concurrence of a number of individuals. They all paſs through various hands: ſome ſketch them, others bring them to a greater perfection, and a third ſort finiſh them. The works of ſolitary animals ſpring from one head only; and the ſame hand that begins them, continues, finiſhes, and repairs them. Each individual has his particular talent, and degree of ſkill, whereby he provides for

for his own fubfiftence, and furnifhes himfelf with all neceffaries.

We will here confine ourfelves to the proceedings relative to the *metamorphofis:* this is an affair of great importance for one of our hermits to prepare himfelf for, the moft interefting to him of any during his whole life. *Caterpillars* alone exhibit to us examples of almoft all the proceedings which nature has taught to infects of this kind. We will limit our examinations to this clafs in particular.

2. There are fome caterpillars whofe bodies are fupported by a prop, and nature has taught them the method of effecting this. They wind a girdle round their body, compofed of a number of filk threads collected together, whofe ends are fixed to the prop that fuftains them. By this means they faften their hind legs in a little heap of filk. It is eafy to imagine after this, that the chryfalis muft be tied and grappled as the caterpillar was. The girdle is loofe, and leaves the chryfalis fufficient room to perform its little operations.

3. Other caterpillars form cones. Some of thefe give their cone a more exquifite form, fo as to refemble that of an inverted boat. The cone of a filk-worm is made, if we may be allowed the expreffion, of a fingle piece. The cones made boat-wife confift of two principal parts, fhaped like fhells, and joined together with great fkill and propriety. Each fhell is worked feparately, and formed of an almoft infinite number of very minute filk rings. On the fore-part of the cone, which reprefents the hind-part of the boat, is a ledge

ledge that juts out a little, in which we may perceive a very narrow crevice, which denotes the aperture contrived for the exit of the butterfly. By means of that, the two ſhells may part aſunder, and leave room for the butterfly to paſs through them. They are conſtructed and put together with ſo much art, that they are of the nature of a ſpring, and the cone from whence the butterfly has lately iſſued appears as cloſe as that which it ſtill inhabits. By this ingenious artifice the butterfly is always free, and the chryſalis in ſafety. We ſhall hereafter come to treat of proceedings which are analogous to theſe, but more ſingular.

4. Our ſpinners have not all an equal proviſion, yet all ſeem to endeavour at concealing themſelves from ſight. Such as are not rich enough to make themſelves a good lodgment of ſilk, ſupply the want of it by different matters of a coarſer or finer texture, which they are ſufficiently ſkilful to cauſe to contribute towards the conſtruction of the lodge. Some content themſelves with giving it a covering of leaves, which they connect together without any art. Others do not confine themſelves to the amaſſing theſe leaves, and diſpoſing them indiſcriminately; but range them with a kind of regularity. Others think proper to powder the whole of their cone with a matter they yield from behind them, and which they cauſe to penetrate betwixt the thread. Others ſtrip themſelves of their hairs, and form a maſs of a mixture of ſilk and hairs. Others, after having ſtripped themſelves, plant their long hairs about them, and make of them a ſort of cradle fence. Others add a greaſy matter, which they

they procure from their inſide, to the ſilk and hairs; with this they ſtop up the rings of the weſt, and it ſerves as a varniſh for them. Others thruſt themſelves into ſand or ſmall gravel, and there conſtruct for themſelves cones of ſand, whoſe grains are connected with the ſilk. Others, laſtly, which have ſilk, pierce the earth, make a cavity in it like a cone, and ſmear the ſides of it with a kind of glue or paſte.

Another ſpecies, which is far more induſtrious than the former, perform a work which we cannot too much admire. You have lately ſeen deſcribed thoſe cones which reſemble an inverted boat: this is likewiſe the form that this ſpecies give to their cone; but they do not make it intirely of ſilk. They ſtrip off little pieces of bark with their teeth, of a rectangular figure, nearly even and alike, and diſpoſe them with all ſkill and propriety; with theſe they compoſe the principal parts of the cone. Theſe great parts are likewiſe formed of a conſiderable quantity of very ſmall inlaid work, placed end to end, and joined together with ſilk. In a word, we are apt to fancy that we are looking at an inlaid floor, or a piece of inlaid work.

5. The moſt ſolitary of all inſects are ſuch as live in the inſide of fruits. Each fruit lodges only one caterpillar or worm. We are ignorant of the cauſe of this remarkable fact. We only know, that a curious obſerver having attempted to cauſe caterpillars of this ſpecies to live together, they furiouſly engaged each other as often as they met. It is then inconteſtably true, that the diſpoſition of theſe caterpillars is antiſociable. Several

veral have metamorphosed themselves in the very fruit that has served them for a retreat and for provision; they dig cavities in it, which they line with silk, or in which they spin their cones. Others, which are the greater part of them, quit the fruit, and metamorphose themselves in the earth.

6. Those insects that roll up or fold the leaves of a great number of plants are also perfect hermits. This proceeding is common to many caterpillars. They thus procure for themselves little cells, which are convenient lodgings for them, in which they are always sure to find nourishment, for they eat the walls of the cell; but they are always very careful never to touch that part which is destined to cover them. The different methods in which these caterpillars lodge themselves, give room for distinguishing them into *tyers*, *folders*, and *rollers*.

The art of the *tyers* is in general the most simple. It consists in joining several leaves together with silk threads, in order to form them into one intire parcel, in the center of which is the lodge of the little hermit.

The procedure of the *folders* supposes more refined operations. They fold the leaves either *in the whole*, or *in part*. In the *whole*, when the portion folded is turned back flat upon another part of the leaf: and in *part*, when they only simply bend the leaf more or less.

But the labour of the *rollers* is most of all to be admired. They live in a kind of roll, whose dimensions, form, and position vary in different species. Some give it a cylindrical figure; others, the form of a cone, which is likewise as well-made

made as thofe the grocers ufe. The leaf is always rolled fpirally, or as *wafers* are. The roll or cone is commonly laid on the leaf; but fometimes, which is very remarkable, it is fixed on it like a nine-pin.

Does my reader imagine that mechanifm prefides over the conftruction of thefe various works? Does he conceive in what manner an infect, that has no claws, is able to roll up a leaf, and to keep it fo? We know in general that caterpillars fpin: and can in fome meafure difcover, it is by the affiftance of their threads that our fkilful rollers caufe the leaves to take the form of a cylindrical or conical tube. We fee in effect parcels of threads diftributed from one diftance to another, which hold the roller confined to the leaf. But how can thefe threads, which feem only to perform the office of fmall cables, be capable of rolling up the leaf? This we imagine ourfelves able to guefs at, but without effect. We fuppofe, that by faftening threads to the edge of the leaf, and drawing thefe threads towards her, the caterpillar forces the edge to rife and turn itfelf; which is by no means the cafe. The ufe the induftrious infect makes of its ftrength, confifts of a more refined mechanifm. He fixes a number of threads to the border of the leaf, but does not draw it to him. By means of them he bends the other extremity to the furface of the leaf. The threads of one and the fame parcel are nearly parallel, and compofe a little ribband. By the fide of this ribband the infect fpins a fecond, which paffes over and croffes the former. This then is the fecret of its mechanifm. In paffing over the firft ribband in order

order to extend the ſecond, it bears on the firſt with the whole weight of its body; this preſſure, which tends to force down the ribband, obliges the edge of the leaf to which it is faſtened, to riſe. The ſecond ribband, which is at the ſame time ſtruck on the flat part of the leaf, preſerves on the edge that alteration or bending which the inſect was diſpoſed to give it. If we narrowly examine theſe two ribbands, their effect will be viſible. The ſecond will appear very tight, and the firſt very ſlack; the reaſon is becauſe the latter has no greater degree of action, nor indeed ought to have. You now comprehend that the roll is gradually formed by the repetition of the ſame operations on different parts of the leaf. But it often happens that the coarſer edges reſiſt too much; the inſect knows how to weaken them by gnawing them here and there. In order to form a *cone*, ſome more performances are neceſſary. The *roller* cuts with her teeth, on the leaf, the part that is to compoſe it. She does not detach it altogether from it; it would then want a baſe; ſhe only ſeparates that part which is neceſſary to form the foldings of the *cone*. The part is properly a ſlip, which ſhe rolls as ſhe cuts it. She raiſes the cone on the leaf, almoſt in the ſame manner as we erect an inclined obeliſk. She fixes threads or little cables near the point of the pyramid; ſhe preſſes on them with the weight of her body, and thus forces the point to raiſe itſelf. You may form an idea of the reſt; the mechaniſm is the ſame as that employed in making a roll.

Theſe cells, in which the caterpillar lives, ſerve likewiſe as a retreat for the chryſalis. This latter would not probably be ſufficiently well accommodated

commodated with a bare covering of leaf. The caterpillar lines the cell with ſilk tapeſtry. Other ſpecies ſpin a cone for themſelves in it.

7. Some leaves of plants are ſcarcely thicker than paper. Would any one imagine there were inſects ſkilful enough to provide a lodging in ſuch thin leaves as theſe, ſo as to ſhelter themſelves from the injuries of the weather? A leaf is to them a vaſt country, wherein they make roads for themſelves that are more or leſs winding; they mine in the ſubſtance of the leaf, as our miners do in the earth. From hence alſo they have taken the name of *miners of leaves*. They are extremely common: ſome belong to the claſs of caterpillars; others to that of worms. They cannot bear to be naked; and it is for the ſake of covering themſelves that they inſinuate themſelves between the two foldings of a leaf. They find their ſubſiſtence there at the ſame time. They eat the pulp of it, and, in eating, trace out a way for themſelves. Some dig there ſtrait or crooked trenches. Theſe are *gallery* miners. Others mine round about them, in circular or oblong ſpaces, theſe are *miners* at large. Their teeth are the inſtruments they mine with; but ſome worm *miners* dig by means of two hooks reſembling our pick-axes. Several of theſe inſects ſpin, within the mine, the cone wherein they are to transform themſelves. Others quit the mine, and metamorphoſe themſelves elſewhere. Butterflies that proceed from *mining* caterpillars, are little miracles of nature. She has laviſhed gold, ſilver, and azure upon them; with other colours that are more or leſs rich; though we regret that ſhe has not performed theſe maſter-pieces in a more extenſive form.

8. But

8. But *miners* have something still more wonderful to offer to us. Bestow your attention on those vine leaves that are before you. They are pierced with *oval holes*, which seem to be made in them by a *gimblet*. The *mining* caterpillars bored these holes, by stripping two pieces of skin from the leaf, with which they make a cone: that cone is there placed perpendicularly on a vine-prop, at a pretty considerable distance from the leaf that furnished the materials. How was it cut, fashioned, detached, and conveyed? Let us not vainly attempt to guess this: let us rather endeavour to surprize the industrious labourer on her working bench. She mines *by way of gallery*, and constructs her cone at the extremity of the gallery. It is composed of two pieces of leaf of an oval form, very thin, even, and like each other. The caterpillar prepares these places; makes of them a thin texture, by clearing them of the pulp; she models them, lines them with silk, cuts them with her teeth as with scissars, joins and unites them. They already have no connection with the leaf, notwithstanding which, the cone does not fall: the caterpillar has taken the precaution to sustain it by some threads of the same species with its border. When the cone is finished, the caterpillar applies herself to disengage and transport it from its place. She has left a small aperture at one end of it. She causes her head to come out at this opening, bears it forward, seizes a part of the prop with her teeth, and by an effort draws the cone to her. The threads that hold it give way, and the caterpillar carries her little house about with her as the snail does her shell. Behold her walking; her march is a new mystery. It has been said that all caterpillars have at least ten legs: this is absolutely

abſolutely without any, and ſhews us what an opinion we ought to entertain of ſuch naturaliſts. Let us lay in her way a finely poliſhed glaſs, placed perpendicularly. She is not in the leaſt retarded by this, but climbs over the glaſs as on a leaf. By what ſecret art is ſhe enabled to cleave to it, for ſhe has neither legs nor claws to grapple it? You have ſeen caterpillars that ſpin little heaps of ſilk which they fix themſelves to. Our *miner* ſpins the like, at certain diſtances, according to the track ſhe is to paſs over. She ſeizes one of theſe heaps with her teeth, which becomes in part a ſupport for her; ſhe draws the cone to her, and carries it towards the little heap; faſtens it to it; thruſts her head forwards; ſpins a ſecond heap; fixes herſelf to it in the ſame manner as to the firſt; makes an effort to diſcharge the cone, which ſhe effects, drags it towards the new heap, faſtens it likewiſe to it, and this ſecond ſtep being taken unravels to you the ſecret of her ingenious mechaniſm. By this means ſhe leaves on the bodies over which ſhe paſſes little tracks of ſilk, which ſhe ſpins from ſpace to ſpace. When ſhe has arrived at the place ſhe is inclined to fix herſelf at, ſhe here ſtops the cone intended for an habitation, and places it in a vertical ſituation. There afterwards iſſues from it a very pretty butterfly, as richly cloathed, and of the ſame genus, as thoſe of other miners.

9. Other inſects live in great galleries of ſilk, which they lengthen and widen as they grow. They cover them with groſs matter, and frequently with their excrements. They conſtruct thoſe galleries on the various bodies they feed upon, and which differ according to the ſpecies of

of the insect. The name of *false moths* has been given to all such species as make those inclosures. You are sensible, that those of *true moths* are portable. The most remarkable false moths are such as settle in bee-hives, and destroy the combs. They are without defensive arms, and are only secured with a soft and delicate skin; notwithstanding which nature has appointed them to live at the expence of a little warlike people that are well-armed, and equally well disposed to defend their settlements. Our engineers have frequently reçourse to mines and sap in the reduction of places. It is indeed abundantly necessary that our false moths should excel in this kind of attack, and their works prove that they do. They never march but under cover. They scoop long trenches in the thick part of the combs, in what direction they think proper, wherein they are always in safety from the enemy. The galleries of this kind are lined within with a very close silk tissue, and covered on the outside with a thick layer of grains of wax and excrements. Thus the fine works of the laborious bees are destroyed in silence by an enemy which they are not able to discover, and that sometimes compels them to abandon their hive. The false moths have no intention to procure honey: they never penetrate into the cells that contain it. They only eat the wax, and their stomach analyzes the matter which the chymist cannot dissolve. When they have attained their full growth, they make a silk cone at the end of the gallery, which they never fail to cover with grains of wax.

Other false moths establish themselves in our granaries, where they multiply excessively. They covet

covet our moſt valuable commodity. They connect together ſeveral grains of corn; they ſpin a little tube in the midſt of this heap, where they lodge. By that means they are always within reach of a plentiful ſtock of nouriſhment. They feed at their pleaſure on the grains of which they have been careful to form their caſe, and which are like a covering to it. When their metamorphoſis approaches, they abandon this caſe; they neſtle in the inner part of a grain, or in the little cavities they dig in the cielings: theſe they line with ſilk, and there transform themſelves into a chryſalis.

10. There are few inſects which claim ſo good a right to our admiration as thoſe that are equally ſkilful with ourſelves in making cloaths, and that undoubtedly learned the art before us. Like us, they are brought forth naked; but they no ſooner come into the world, than they ſet about cloathing themſelves. They do not all dreſs in the ſame uniform manner, nor do they uſe the ſame materials in their cloathing. There is perhaps a greater diverſity with reſpect to this in the modes of different ſpecies of moths, than in thoſe of different people on the earth. The form of their dreſs is very convenient: it correſponds exactly with that of their body. It is a little cylindrical caſe, which opens at both ends. The ſtuff is manufactured by the moth: the ground of it is compoſed by a mixture of ſilk and hair: but this would not be ſoft enough for the inſect, it is therefore lined with pure ſilk. Our woollen furniture and furs ſupply theſe moths with the hair they employ in manufacturing their ſtuffs. They make a careful choice of theſe hairs; cut them with their teeth, and artfully incorporate them in

the ſilk tiſſue. They never change their cloaths: thoſe they wore in their infancy, they continue to wear when arrived at maturity. They can then lengthen or widen them as they find convenient. They meet with no difficulty in extending them; this they do by only adding new threads and hairs to each end. But the widening them is not ſo eaſy a matter. They proceed herein exactly as we do in the like caſe. They ſlit the caſe at the two oppoſite ſides, and ſkilfully inſert two pieces of the width required. They do not ſlit the caſe from one end to the other: if they did, the ſides would ſtart aſunder, and be expoſed. They only ſlit each ſide about the middle of it. Reaſon itſelf could not exceed this. Their dreſs is always of the colour of the ſtuff from whence it was taken. If therefore a moth, whoſe cloathing is blue, paſſes over a red piece of cloath, the widths will be red; ſhe will make herſelf a harlequin's habit, if ſhe paſſes over cloths or ſtuffs of ſeveral colours. They live on the ſame hairs they cloath themſelves with. It is remarkable, that they are able to digeſt them; and it is ſtill more extraordinary that the colours do not ſuffer the leaſt alteration by digeſtion, and that their excrements are always of as fine a tincture as the cloths they feed on. Painters may collate from our moths powders of all colours, and all kinds of ſhades of the ſame colour, They make little journies: thoſe that ſettle in caſes, do not love to walk on long hairs, but cut all they meet with in their way, and are always provided with a ſcythe as they march. They reſt themſelves from time to time, when they fix this caſe with ſmall cords, and thus cauſe it as it were to ride at anchor. They faſten it more firmly, when they are

are disposed to metamorphose themselves. They close up intirely both ends of it, in order to cloath in it the form of the chrysalis, and afterwards that of the butterfly.

11. *Field* moths greatly exceed the *domestic* moths in point of industry. They take the substance of their cloathing from the leaves of plants; but it becomes necessary for them to prepare this matter, and give it that lightness and flexibility proper for the garments. These moths are of the species of *miners*; and they insinuate themselves betwixt the two membranes of a leaf, which are to them what a piece of cloth is to a taylor; with this difference, that the latter has occasion for a pattern, which the moths can dispense with. They remove from these membranes all the pulpy substance that adheres to them, which membranes they make thin and polish. They afterwards cut in them, thus prepared, two pieces, which are nearly equal, and like each other; they labour to give them the hollowness, windings, and proportions which the form of their case requires, and this form is often of an exquisite kind. They connect and unite them with incredible skill, and conclude by lining them with silk. They have then nothing to do but disengage the cloathing from within the leaf where it was taken and cut, and that requires but a few efforts.

12. Many *field* and *aquatic* moths do not prepare the stuff for their cloathing. Bits of wood, little sticks, fragments of leaves, pieces of bark, &c. placed on each other like tiles, compose the external cloathing of the case, which consists of

pure ſilk. At other times it is covered with gravel, pebble-ſtones, pieces of wood, little bits of reed, and ſmall ſhells either of muſcles or ſnâils, and, what is ſcarce credible, the ſnails and muſcles continue to live in theſe ſhells; for, being in a manner chained to the caſe, they are obliged to follow the moth, that carries them wherever it pleaſes. Thus a moth in its cloathing does not appear unlike certain pilgrims. Thoſe that are covered with wood, gravel, ſtones, and other unwieldy matters connected together, pretty nearly reſemble a Roman ſoldier in heavy armour. You rightly judge, that ſuch kind of clothes muſt needs be very roughly formed: but ſome of them nevertheleſs look very pretty, in which the arrangement of the materials makes amends for their coarſeneſs. Aquatic moths reap ſome advantage by dreſſing themſelves in ſuch a ſtrange manner. They muſt be always in equilibrio with the water in the midſt of which they live. If their caſe prove too light, they add a little ſtone to it; if too heavy, they faſten ſome bits of reed to it. All theſe moths metamorphoſe themſelves in their caſe; ſome into butterflies, others into flies, and others into beetles.

13. Some *field* moths borrow no ſtrange matters to cloath themſelves with; they dreſs intirely in ſilk; but their tiſſue is much cloſer, finer, and more gloſſy, than that of the moſt beautiful caterpillars. It has a ſtill greater ſingularity; being compoſed of little ſcales, like thoſe of fiſhes, partly placed on each other. The caſe has ſometimes for its laſt covering a kind of mantle, which almoſt intirely incloſes it, and is compoſed of two principal pieces, whoſe figure reſembles that

that of a *bivalve* ſhell. Moths that procure the matter for their cloathing from their own fund, muſt be able to lengthen and widen it at pleaſure; the expence attending the obtaining of it was too great to admit of their making a new one as often as there ſhould be occaſion. So that they are able to enlarge it in a wonderful manner. They do not add *breadths* to it as the domeſtic moths do: but ſlit it from one part of it to another, according to its length, and immediately fill up the intervals with new threads, of a length proportioned to the ſpace required. This caſe ſerves them likewiſe as a kind of cone, wherein they transform themſelves into butterflies.

You have taken a ſurvey of the produce of a multitude of different inſects, and are with good reaſon aſtoniſhed at the prodigious variety contained in them, all relative to one and the ſame general end, and all of them likewiſe as much diverſified as thoſe of our artiſans. How does it happen, that amongſt ſo many inſects as prepare themſelves for their metamorphoſis, ſome hang by their hind-part, others faſten themſelves with a girdle, whilſt others make themſelves cones? How comes it to paſs, that of thoſe that conſtruct theſe cones, ſome form them of pure ſilk, and others compoſe them of matter of different kinds? Why is the form of theſe cones ſo various in different ſpecies? Wherefore do ſome inſects ſo artfully roll up the leaves of plants, and others only faſten or fold them together? How can we account for the mining of theſe leaves by ſome only, and that the reſt ſhould not all mine them in the ſame manner? In ſhort, how ſhall we aſſign a reaſon why the moths are not all clothed in the ſame dreſs?

All these *wherefores*, and a thousand others that may be formed on the productions of nature, are so many enigmas proposed to beings that are banished into a corner of the universe, and whose sight, as short as that of the mole, can only perceive the nearest objects, and the most direct and most striking relations.

It behoves us to remain in the place that has been allotted for us, from whence we can only discover some links of the chain. One day we shall discover more of them, and shall see them more distinctly. Mean while we may consider these proceedings of insects, so diversified and replete with industry, as an agreeable spectable exhibited by nature to the eyes of the observer, that furnishes him with an inexhaustible source of reflective pleasure and useful instruction. He is led to the AUTHOR of the universe by the thread of the caterpillar, and he admires in the variety of their means, and in their tendency to the same end, the fecundity and wisdom of the ORDAINING MIND.

This sight becomes still more interesting, when the observer undertakes to bewilder insects, and draw them from their natural track. They then shew him resources, which he had not foreseen, and that surpass his expectation. When false moths of the wax species are in want of wax, they can make galleries of leather, parchment, or paper. A caterpillar has been seen to construct a cone of little pieces of paper which have been given him, and that have been cut at pleasure. It has taken hold of them with the teeth and fore-legs, transported them to the place where it intended

intended to fix, ranged them there, faſtened them with threads, laid ſome of them edge-wiſe, others flat, forming of the whole, it is true, an aſſemblage that appears a little ſtrange, but anſwering perfectly to a cone. It would have given it a more regular figure, had it worked with materials ſuited to its ſpecies. Ere we had learnt to prepare and dreſs woollens and ſkins of animals, the *domeſtic* moths were not without cloathing. They were then perhaps habited in the ſame manner as the *field* moths.

14. We do not expect to make any material diſcoveries from *ſhell-fiſh* that are ſhut up in an almoſt ſtony incloſure; they ſeem very ſtupid; but they are not all ſo ſenſeleſs as they appear to be: we ſhall with pleaſure contemplate the proceedings of ſome of them.

Divers ſpecies of ſea ſhell-fiſh are furniſhed with two pipes, by means of which they ſuck in the water, and which they take great care to keep raiſed above the veſſel they are accuſtomed to ſink into more or leſs. Some ſpurt out the water to the diſtance of ſeveral feet. That particular part which in ſome performs the progreſſive or retrograde motion, very much reſembles a real leg with a foot joined to it; but this leg is a Proteus, which aſſumes all kinds of forms to ſupply the neceſſities of the animal. It does not only make uſe of it to crawl with, ſink into a veſſel, or retire from it; but employs it with much greater ſkill to perform a motion that one would not imagine a ſhell-fiſh capable of. A ſhell-fiſh that leaps, muſt appear very extraordinary. 'Tis a *tellina* that you are now ſeeing. You may obferve that fhe has placed the fhell on the top or point. She ftretches out her leg as far as poffible; fhe caufes it to take hold of a confiderable part of the circumference of the fhell, and, by a fudden motion, fimilar to that of a fpring that is flackened, ftrikes the ground with her leg, and thus leaps to a certain diftance.

15. The *cutler* never creeps: it penetrates perpendicularly into the fand. It there digs itfelf a fort of cell, which is fometimes two feet long, in which it goes up and down at pleafure. Its fhell, whofe form a little refembles that of the handle of a knife, has occafioned it to receive the name of *cutler*. It is compofed of two long pieces, hollow like a gutter, and joined together by membranes. The body of the animal is inclofed in a cafe. The part whereby it exercifes all its motions, is placed in the center. This is principally defigned to perform the office of a leg, and acquits itfelf exceeding well. It is flefhy, cylindrical, and pretty long. The extremity of it, when neceffary, can roll itfelf up like a ball. View the cutler when extended on the fand. You behold it working, in order to pierce into it. It thrufts out its leg at the lower end of the fhell; ftretches it, and caufes the extremity of it to affume the form of a fhovel that is fharp on both fides, and terminates in a point. It directs it towards the fand, and applies the edge and point for introducing it farther. After the aperture is made, it extends its leg ftill more, and caufes it to penetrate deeper into the fand: he bends it like a hook, with which taking hold of a fupport, he draws the fhell to him, forcing it upright by degrees, and afterwards caufes it to defcend into the

the hole. Is he diſpoſed ſtill to continue ſinking? He thruſts his whole leg out of the ſhell; fixes in the ſand the ball which is then at its extreme part; immediately contracts this leg; his large head, which is ſtrongly fixed in the hole, being leſs inclined to reaſcend than the ſhell is to go downwards, the cutler deſcends into the ſand, which is his firſt ſtep into it; he has nothing to do but to repeat the ſame operations, in order to advance farther and farther into it. Is he diſpoſed to go up again to the ſurface? He puſhes forth the ball, and at the ſame time makes an effort to extend his leg; the ball, which is averſe to a deſcent, preſſes the ſhell towards the top of the hole. It is pretty remarkable, that the cutler, which lives in ſalt water, dreads the touch of ſalt. If a pinch of it be caſt into his hole, he will come out of it immediately. But if he be caught, and afterwards permitted to re-enter his cell, it will be in vain to throw ſalt into it, ſince he will not quit it on that account. It is ſaid by ſome, that he remembers having been taken; and this is ſo true, that when people do not catch him, he may be made to come out at one's pleaſure, by throwing ſome freſh ſalt into the hole. It ſeems, then, that he is aware of the ſnare that is laid for him, and is unwilling to be taken by it.

16. Caſt your eyes on this ſtone, which I have juſt now taken up from the ſea-ſhore. A ſhell-fiſh fixes his habitation in it. Obſerve, that on the ſurface of the ſtone there is a very little hole; it is by that the ſhell-fiſh has entered, and you may judge of the ſmallneſs of it by that of the aperture. We will break the ſtone aſunder, that we may ſee the animal that dwells in it. How

great muſt your ſurprize be! You behold a great ſhell-fiſh, near three feet in length, whoſe ſhell is formed of three ſmooth pieces joined together by a ligamentary membrane. It is lodged in a great cavity, that is hollow like a funnel. The upper part of the cone is in the little hole you ſee on the ſurface of the ſtone. This ſhell-fiſh is a *dail* or pholas. How could it be able to pierce ſo hard a ſtone? Or how go through ſo narrow a paſſage? Draw near this clayey ſhell which the wave has juſt left. It is pierced through with a multitude of ſuch holes as you ſee in the ſtone you have in your hand. All theſe holes are inhabited by young dails, which are only a few lines long. They had then no occaſion to penetrate into a hard ſtone. Moiſt clay makes but little reſiſtance. But the ſea inſenſibly converted this clay into ſtone: the dail, which at firſt found himſelf lodged in a ſoft earth, afterwards perceived that he was within a ſtone cell. We have ſeen that the cutler can come out of his hole when he pleaſes: the dail never quits his; nor indeed can he; ſince the form of this kind of cell will not admit of it. All that he can do is, to ſtretch out two pipes at the opening of the hole, with which he receives and rejects the water. The cutler does the ſame. You are impatient to be informed of the inſtrument with which the dail hollows his cell. This inſtrument has no edge to it: it is purely fleſhy, and ſhaped like a lozenge.

17. We will quit ſhell-fiſh for a time. Divers animals of the ſea will likewiſe entertain us with the wonders of their Author. Let us beſtow on them the attention they deſerve: what we are about

about to relate concerning them, will be found well deserving notice in natural theology.

On the rocks near the sea-shore you may perceive little fleshy masses, of the size of an orange, whose form is like that of a counter-bag, and pretty nearly resembling that of a cone when cut. All these masses seem immoveable, and connected with the rock by their base. Some of them are rough, others smooth. We have just now compared them to a bag or purse, in which counters are put; but this bag is not folded together, and is likewise without strings. They are nettles that you see; a very singular kind of animals, that demand a closer attention. The body of the animal is in effect inclosed within a sort of fleshy purse, of a conic figure. At the top of the cone is an opening, which the nettle increases or contracts at pleasure.

Let us consider the *sea-nettles* that we have now before us: there is one that opens and unfolds itself like a flower: it has put forth an hundred and fifty fleshy horns, like those of snails, distributed in three rows round the aperture. You remark, that little water-spouts issue from these horns; consequently they do not perform the same functions as those of snails; they are analogous to the pipes of dails, cutlers, and other shell-fish which you have seen. You also remark, that the form of these nettles varies greatly, that their base is sometimes circular and sometimes oval, and that the height of the cone varies according to the dimensions of its base. It rises or falls as the base grows narrower or wider. Touch one of these blown nettles: see with what quick-

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ness it closes and contracts itself. But you perceive no progressive motion: are the nettles then condemned to pass their whole life fixed to the same spot? The ancients thought so. What are we to think of them? About an hour ago, this large nettle, which you see on your right hand, touched this point of the rock: observe that it is now above an inch distant from it. You are surprized that you did not perceive it walk, for you looked at it more than once; the reason of this is, because its progressive motion is as slow as that of the hand of a clock. We may be curious to know how the nettle performs it. All its body is externally furnished with various orders of muscles. Those of the base go, like rays, from the centre to the circumference; others descend from the top towards the base. These muscles are also canals, full of liquor, which issues out on pricking them. They are emptied and filled at the pleasure of the nettle. By the exercise of these muscles or canals, the progressive motion is performed. Let us follow the nettle when she is disposed to go forwards. Her base is circular. She swells the muscles that are on that side whither she is tending. She injects her liquor into them, which, by inflating, lengthens them. They cannot extend themselves unless the edge corresponding with the base shifts its place, and advances a little way. At the same time she loosens the opposite muscles, and empties their canals. They contract. This they cannot do, except the edge of their corresponding base goes in a little, and exactly in the same degree as the opposite one projects. Such is the mechanism whereby the first step of our nettle is performed. In order to make a second, she causes the base again to receive

ceive a circular form, by puffing up equally all the canals: ſhe afterwards repeats the ſame operations we have juſt taken a view of.

The whole progreſſive motion of nettles is not confined to this. They have another method of walking, which more nearly reſembles that of inſects. They are able to make uſe of their horns like legs. But theſe horns are on the upper part of their body: the nettle is fixed by its baſe againſt the rock: how do theſe horns perform the office of legs? The nettle you are following will ſhew you the method. She turns herſelf upſide down; the baſe abandons the rock, and the cone is placed on its top. All the horns ſhoot forth, and you ſee them fix themſelves to the rock. They are glewy and rough to the touch: for which reaſon they meet with no difficulty in faſtening to it.

18. Would you believe that an animal which is entirely of a fleſhy nature, and is provided with no inſtrument to open or pierce the ſhells, feeds upon ſhell-fiſh? Nettles that are but of a middling ſize ſwallow great ſhell-fiſh, and it is difficult to conceive how they are capable of being lodged within the nettle. It is true, the latter being entirely fleſhy is ſuſceptible of a great diſtenſion. It is a ſort of ſupple purſe, that may be ſtretched occaſionally. The opening of the purſe is properly the mouth of the nettle. Its inſide not being tranſparent, one cannot ſee what paſſes therein, or by what means the nettle voids the ſhell-fiſh. The moment ſhe has ſwallowed it, ſhe cloſes herſelf. Look at this young nettle that is ſhut up quite cloſe: ſhe has juſt ſwallowed a pretty large ſnail, and is buſy in digeſting it. She

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is now opening herſelf again, and diſcharging the empty ſhell. On the ſide of her is another nettle which beſpeaks your attention: ſhe has ſwallowed a great muſcle, and is making ineffectual efforts to void the ſhell. She is not able to effect it: the ſhell preſents itſelf in an unfavourable poſition at the aperture, and you begin to be in pain for the unhappy nettle. She has a reſource that you did not imagine. Caſt your eyes towards the baſe; the ſhell is evacuated through a large wound; the nettle is delivered from it by that means, and is no more affected by the great gaſh made thereby, than we are by a ſcratch.

19. All nettles do not procure a diſcharge by ſo violent a method: they have another, which they commonly uſe with ſucceſs. They turn themſelves inſide out like a glove or ſtocking, ſo that the edges of the opening, which reſemble lips, fold themſelves on the baſe. The mouth is then of a prodigious width, and the bottom of the purſe almoſt uncovered.

Nettles do not thus ſhift themſelves merely to get rid of heterogeneous bodies; they put themſelves into the ſame poſture when they bring forth. They are viviparous. The young are produced completely formed; and we ſee nettles in miniature appear. The aperture through which they paſs, is ſo wide as to admit a multitude of them at the ſame time. Notwithſtanding which, they always come forth ſingly. They are at firſt incloſed in certain folds concealed at the bottom of the purſe.

Do nettles resemble polypuses by the singular property of being multiplied and grafted by slips? Experiments have put this beyond all doubt. Of a single nettle, divided according to its length or width, are made two or three, which at the end of a few weeks are perfect and complete. They may likewise be grafted; but it will be necessary to have recourse to *seaming*. You are now no longer surprized at the consolidation of that enormous wound made at the base of a nettle that issues out thereat. A wound of this nature is nothing, when compared to that which another animal sustains when cut in pieces, without ceasing to live and multiply in each piece. Nettles may then be called a species of *polypuses with arms* of a monstrous size; or, if you prefer the expression, *polypuses with arms* are a species of very minute *nettles*.

Let us quit these rocks that swarm with nettles, and betake ourselves to that little creek where the sea is very calm. Stoop a little, and observe the surface of the water. What do you perceive? A kind of greenish jelly floating upon it. Its form is like that of a broad mushroom. It is near two feet in diameter. Take a piece of it betwixt your fingers; handle it for a few minutes: you will see it dissolve into water. The heat of your hand was sufficient to melt it. Does it enter into your thoughts that this jelly is a real animal, and even a species of nettle? It has been called *wandering nettle*, because it never fixes, and floats from one side to the other. Its convex surface presents us only with an infinite number of little grains or nipples. But its inferior surface, which is concave, is extremely organized: in that we may

may ſee a great number of canals, which are regularly diſpoſed, and made with great art, ſome being circular, and others diſpoſed regularly, like the felloes of a wheel, and which are full of a watry liquor, which paſſes from one to the other.

This ſtrange animal wanders about in the ſea. It is ſpecifically much heavier than water. He cannot therein ſuſtain himſelf, without the aſſiſtance of a ſpontaneous motion, which is worth obſerving, and cannot be ſeen but in places where the water is calm. It is ſo in this little creek on the extremity of which we are ſitting. Look with attention on the ſurface of that jelly which offers itſelf to your view. Obſerve that it has certain motions, which you are tempted to compare with thoſe of the *ſyſtole* and *diaſtole*. However, they are not the ſame. Their only end is to cauſe the nettle to float. You ſee that in the ſyſtole kind, the ſurface of the animal becomes very convex, and that in the diaſtole it becomes ſuddenly flat and wide. Such is our glutinous nettle's method of floating. When dried in the ſun, it is reduced almoſt to nothing. We imagine that we ſee a little piece of parchment or very tranſparent paſte. There is no room to doubt that this ſpecies of nettle multiplies, like the reſt, by ſlips; but I do not know that there has been any experiment made concerning this. A jelly muſt be attended with greater eaſe in regenerating itſelf than organized bodies of the ſame genus, that are of a more firm and cloſe conſiſtence.

20. There are no regular or ſtrange forms of which the animal kingdom does not afford us models. Here is an animal whoſe form is preciſely

cifely that by which we paint the ftars in the firmament. It is nearly flat. From the middle of its body proceed four or five rays, which are almoft equal, and refembling each other. Its upper furface is covered with a hard, callous, and very rough fkin. In the centre of the inferior furface is placed the mouth, which is provided with a fucker, that the ftar makes ufe of to imbibe the fubftance of the fhell-fifh fhe feeds upon. Five fmall teeth or pincers hold it confined whilft fhe fucks them, and perhaps affift in the opening his fhell. The legs of the ftar are a real curiofity. They are joined to her inferior furface, and diftributed with fymmetry in four rows, each confifting of feventy-fix feet; fo that each ray is furnifhed with three hundred and four feet, and the whole ftar with fifteen hundred and twenty. Yet with fuch a number of feet, the ftar goes but little fafter than the mufcle, which has only one. Thefe legs perfectly refemble the horns of the fnail, both by their figure, confiftence, and exercife. When the ftar is difpofed to walk, fhe fpreads her legs as the fnail does her horns, and with the extremity of them feizes the various marine bodies on which fhe crawls. She commonly puts forth only one part of her legs; the remainder are kept in referve againft thofe neceffities which may happen. The mechanifm which prefides over their motions is an illuftrious proof of a CREATIVE MIND. Let us open one of the rays by flitting it lengthwife, and we fhall difplay the principal fprings of the machine. An almoft cartilaginous partition, made in the form of vertebræ, divides the whole ray. In every part of this partition you perceive two rows of little balls, like pearls of the fineft water. The number of thefe little balls

balls is precifely equal to that of the legs. Thus you fee that each ball anfwers to a leg. You can diftinguifh a limpid liquor in thefe balls; prefs your finger upon them; they empty themfelves; the liquor paffes into the correfponding legs, and they immediately extend themfelves. The ftar then need only prefs the balls in order to fpread the legs. But they are capable of contraction, and when they contract themfelves, they force the liquor back again into the balls, from whence it may be driven afrefh into the legs, to procure a progreffive motion.

You conjecture, that thefe eggs, which refemble thefe tubes through which divers kinds of fhell fifh refpire, ferve likewife for the fame ufes. But nature, who has been fo lavifh in providing the ftar with legs, has been alfo liberal in beftowing on it the organs of refpiration. She has even multiplied them in a greater degree. They are very fmall conic tubes, difpofed in knots, and produce an equal number of little water fpouts.

Amongft our ftars, you obferve there are fome which have only two or three rays, and by looking more narrowly at them, you difcover feveral very minute rays, juft beginning to fhoot out. Are then animals, that are formed a repetition of fuch agreat number of parts, both outward and inward, regenerated like polypus's, whofe ftructure appears fo fimple? Nothing is more true, and the ftars you are now looking at, will afford you a proof of it. Thefe animals often chance to lofe two or three of their rays, and they are no more affected by this lofs than polypus's are by parting with fome of their arms. We may mangle ftars or cut them in pieces, but cannot deftroy them by that method

method. They will recover from their ruins, and each piece becomes a new ſtar.

21. *Sea-hedgehogs*, like the land ones, derive their names from their prickles. But thoſe of the former are quite different from ſuch as belong to the latter.

The form of theſe hedgehogs is that of a round button. It is hollow within, and its ſurface is elaborately wrought. We might compare the workmanſhip of them to that of certain copper or wire buttons. A multitude of tubercles, like little triangles divide the whole ſurface of the button. Theſe triangles are ſeparated by ſtripes, which are regularly ſpaced, pierced with holes, and diſtributed with great ſymmetry in ſeveral lines. Theſe holes paſs through from one part to another, the whole thickneſs of the ſkeleton, for the body of our hedge-hogs is a kind of bone-box. Each hole is a ſocket; wherein is a fleſhy horn, like thoſe of a ſnail, and ſuſceptible of the ſame motions. There are therefore as many horns as holes, and there are reckoned to be at leaſt three hundred. The hedgehog, like the ſnail, makes uſe of her horns for feeling the earth, and the various bodies it meets with in its paſſage. But it particularly employs them to faſten with and caſt anchor. The tubercles are the baſes of many prickles or legs, and their number amounts to at leaſt two thouſand one hundred. So that there is hardly any part of the body of a hedgehog that is deſtitute of a leg. It can for that reaſon walk as well on the back as on the belly; and in general, let it be in what poſture it will, it has always a great number of legs ready to carry it, and horns to fix it with. The legs it uſes with the greateſt eaſe are thoſe which ſurround

ſurround the mouth; but when it pleaſes, can walk by turning round on itſelf like a wheel. On the back or the top of the button, is another aperture which is thought to be the anus. This then is an animal that is provided with at leaſt thirteen hundred horns, and two thouſand one hundred legs, What a great number of muſcles muſt it require to move ſo many horns and legs? How many fibres muſt there be in each of theſe muſcles? What an aſtoniſhing multiplication of parts in this little animal! What regularity, what ſymmetry, and even harmony in their diſtribution! What variety in their exercife!

When the hedgehog would advance, he draws himſelf forwards with thoſe legs that are neareſt the place he would go to, and puſhes himſelf towards it with the oppoſite ones. All the reſt remain at that time in a ſtate of inaction. At the ſame time that one part of his legs are at work, the horns that are neareſt to them exert themſelves to ſound the way, or find anchorage for the animal.

22. Moſt ſhell-fiſh are produced with their cloathing. The ſhell they bear grows with them and by them. But *Bernard the hermit*, a kind of cray-fiſh ſo called, comes into the world without a ſhell, though he has need of one in order to cover the greater part of his body; whoſe thin and delicate ſkin would ſuffer too much from being naked. Has nature then behaved to it as a ſtep mother, by denying it ſo neceſſary a garment? By no means: as ſhe is beneficent towards every other animal, ſo has this likewiſe been the object of her attention. It is true, ſhe has not provided it with a ſhell; but has made it amends by enabling

it

it to cloathe itſelf with one. Taught by ſo great a miſtreſs, our hermit has the ſagacity to take up his lodging in the firſt empty ſhell he meets with. He applies himſelf indifferently to all that are of a ſpiral conſtruction. He often retires ſo far into them, as not to be perceived, whereby the ſhell appears empty. If the ſhell ſhould prove too narrow, he quits it, in order to ſeek for another, more ſuitable to his bulk. It is ſaid, there ſometimes happen conteſts between our hermits about a ſhell, and that victory is decided in favour of him who has the ſtrongeſt claws. Our battles have ſcarcely ever a cauſe of equal importance for their object.

23. You have been already aſtoniſhed at the ſkill diſplayed in the progreſſive motion of ſeveral ſhell-fiſh, your amazement will be redoubled when you learn that ſome of them can ſpin; and you are impatient to ſee them at work. Let us walk on the ſea ſhore. You there diſcover a number of muſcles, ſome by themſelves, and others joined in companies. Conſider them more attentively you will obſerve that ſome of them are faſtened to ſtones or to each other, by a great number of ſmall ſlender ſtrings, Let us ſelect one of theſe muſcles, that we may obſerve it more cloſely; the better to diſcover their operations. Here is one of them endeavouring to fix itſelf to this ſtone that is near the ſurface of the water. The ſhell is partly open; it has thruſt out from it a kind of ſupple tongue, which it lengthens and contracts alternately. Remark that it often applies the ends of it to the ſtone, and immediately draws it back again into the ſhell, that it may again put it forth the next moment. From the root of this kind o

tongue

tongue there iſſue certain threads, which are equal in ſize to an hog's briſtle. Theſe threads part from each other as they come out, and their extremity ſticks to the ſtone. Theſe are as ſo many ſmall cables which hold our muſcle at anchor. There are frequently an hundred and fifty of theſe little cables employed in mooring a muſcle. Each cable is ſcarcely two inches long.

The muſcle herſelf has ſpun all theſe cords. The tongue not only ſerves them as it does other ſhell-fiſh, for arms to faſten themſelves with, and for legs to creep with; but is alſo the ſpinning inſtrument which produces thoſe numerous threads, by means of which the muſcle reſiſts the impulſe of the waves. From the root of the tongue to its extremity there is a groove, which divides it according to its length into two equal parts. This groove is a real channel, furniſhed with a great number of ſmall muſcles that open and ſhut it. In this channel is contained a viſcous liquor, which is the matter of the threads emitted by the muſcle. At its firſt appearance this channel is exactly cylindrical, and is, properly ſpeaking, the place where the threads are moulded. The various motions the tongue of the muſcle we are obſerving gave itſelf a minute ago, all tended to fix it to the ſtone. Thoſe threads which are the whiteſt and moſt tranſparent are ſuch as are newly ſpun. She has not yet finiſhed anchoring herſelf, wherefore you perceive her tongue is again extending about two inches, and the tip of it drawing towards the ſtone. The viſcous liquor runs in the channel, and arrives at the extremity of it. This liquor is now conſolidated, and become a cylindrical thread. The muſcle ſticks the end of this thread to the ſtone; but is deſirous of applying it by a

wider

wider furface, in order to render it more adherent. For that purpofe, fhe adds to it with the tip of her tongue, that little pafte which you obferved. Her bufinefs now is to extend another cable to fome diftance from the laft. The tongue therefore muft quit this latter, in order to work elfewhere. How will fhe be able to effect this? The channel opens itfelf to its utmoft length, and difcharges the thread. The tongue being difengaged from this thread, quickly draws itfelf together, re-enters the fhell, and the next moment again iffues from it, to fix a new cable a little farther off.

Did you take notice of a mark of fkill expreffed by our mufcle? She has juft now fpread the firft thread; to affure herfelf of the goodnefs of it, fhe immediately puts it to the proof; drawing it ftrongly towards her, as though fhe would break it. It has refifted this effort, and, fatisfied with the experiment, fhe has proceeded to ftretch out the fecond thread, which fhe has tried like the firft.

Thefe cords which the fea mufcles fpin with fo much art, are in reality as ferviceable to them as cables are to a fhip. You afk me, whether they can weigh anchor? Divers experiments prove they are not endued with that ingenuity. It was not neceffary for them. But they fometimes drive with their anchors; it therefore behoves them to have frefh cables in referve.

Thus the fea has its fpinners as well as the earth. Mufcles are at fea the fame that caterpillars are on land. There is neverthelefs a remarkable difference between them. The work of caterpillars anfwers anſwers exactly to that of gold wire-drawers. The ſilk thread is moulded by paſſing through the mouth of the ſpinner, and the caterpillar gives it what length ſhe pleaſes, which in certain cones conſiſts of ſeveral hundred feet. The labour of muſcles may be rather compared to that of workmen who caſt metals. The ſpinning inſtrument of theſe ſhell-fiſh is a real mould which does not only determine the thickneſs of the thread, but alſo its length, which is always equal to that of the ſpinning inſtrument or tongue.

The *pinnæ marinæ*, which are a ſpecies of very large muſcles, are more dextrous ſpinners ſtill. Their threads which are at leaſt ſeven or eight inches long, are extremely fine, and curious works are made with them. If muſcles are caterpillars of the ſea, pinnæ are its ſpiders. The threads of the pinnæ ſerve, like thoſe of muſcles, to moor them with, and defend them from the agitation of the waves. They are prodigiouſly numerous, and being united, form a kind of tuft or ſkain, weighing about three ounces. The inſtrument that prepares and moulds them, reſembles, in the eſſential properties of it, that of other ſhell-fiſh of this kind: except that it is much larger, and the groove that divides it lengthwiſe is much narrower. At the root of it there is a membranous bag, compoſed of ſeveral fleſhy layers, that ſeparate the ſilk layers from whence the tuft reſults.

24. If all kinds of ſhell-fiſh and ſea-animals have not been enabled to moor themſelves with as much ſkill as muſcles and pinnæ, nature has made them amends for that by affording them means that are no leſs efficacious. Before we quit this ſhore, let

let us ſtop a little while and examine this ſmall ſhell-fiſh which you ſee faſtened to this rock. It is a *goat's eye*, or a *limpet*. Its ſhell, which conſiſts of one piece only, is made like a conic chapiter, under which the whole body is ſheltered, as under a roof. The animal can raiſe or lower this covering as it pleaſes. When it lowers it, the body is intirely concealed, and it reſts immediately on the ſtone. A large muſcle that occupies the whole extent of the ſhell, and that is as it were the baſe of it faſtens the animal to this ſtone. Try to diſengage it from it; you are not able to effect it. It is nevertheleſs only fixed to the ſtone by a baſe of an inch and an half in diameter. Let us hoiſt a cord round the ſhell; and ſuſpend a weight of twenty eight or thirty pounds to this cord, the ſhell-fiſh will not quit its hold till after ſome ſeconds, and you are ſurprized that ſo ſmall an animal ſhould be endued with ſo great a power of adheſion. You are curious to know from whence he derives this; you examine the ſtone, and it appears to you to be finely poliſhed, whereupon your aſtoniſhment is redoubled. Can it be that the muſcle is able to inſinuate itſelf into the inſenſible parts of the ſtone? Divide the animal tranſverſely: it ſtill adheres as ſtrongly as before. Does it cleave to the ſtone as two pieces of poliſhed marble cleave to each other? But pieces of marble eaſily ſlip each other; and you cannot cauſe the ſhell-fiſh ſo to do. This then is the ſecret cauſe of that adheſion which aſtoniſhes you. The muſcle is furniſhed with a viſcous humour, which agglutinates it to the ſurface of the ſtone, and which is ſenſibly felt by touching it with the finger.

But the goats eye has not been condemned to remain its whole life affixed to the same place. It is necessary for it to go in search of its food. There is one now creeping on the rock: its great muscle serves him instead of legs, and performs the same functions as that you have been made acquainted with in the snail. The goat's eye then can disengage himself when he pleases. It is able to break those strings which are with difficulty disjoined by a weight of eight and twenty pounds. Moisten your finger, and stroke the muscle with it; the natural glutinous substance, with which it is endued, can no longer retain its hold. This glue is dissoluble by water. The whole surface of the muscle abounds with little seeds, filled with a dissolvent liquor. When the animal is disposed to shift his quarters, he need only press his numerous glands, the dissolvent issues from them and the cords are broken.

The goat's eye has but one certain provision of gluey matter. If it be loosened from its place several times together, its stock will be exhausted, and it will not fix any more.

This method of mooring is common todivers sea-animals. It is particularly so to *nettles*. Its whole skin is one entire mass of glue, which dissolves very speedily in aqua vitæ. It is with this abundant glue that these extraordinary animals fasten themselves to the rocks.

Star-fishes also fix themselves by the same method. A viscous matter is conducted to the extremity of the horns that serve them instead of legs. These legs become strong ties to them by means of the glue that exsudes from them, and when

when they are once faſtened, it is eaſier to break than ſeparate them. The horns of hedgehogs are exactly of the ſame nature.

All theſe adheſions are voluntary, and depend ſolely on the good pleaſure of the animal. He joins or disjoins himſelf as circumſtances require. But there are other adheſions, which are altogether involuntary. Sea-worms that are called *pipe*-worms, are incloſed in a round tube, of a ſubſtance reſembling that of ſhells, and faſtened to ſtones or hard ſand, or even to other ſhell-fiſh. This tube follows the turnings of the ſurface to which it is fixed. The worm never quits this ſhell which he lengthens or widens as he grows. They recall to your remembrance the falſe moths: this may be termed, a *falſe moth* of the ſea. It emits from its whole body a ſtony juice, which is the matter whereof the tube is formed.

Other worms of this ſpecies, whoſe juice is not of a ſtony nature, but glutinous, make uſe of it for collecting round them grains of ſand, or bits of ſhells, and this ſhell of inlaid pieces is notwithſtanding wrought in pretty exact proportion.

Oyſters, and many other ſhell-fiſh, adhere by a ſtony liquor to the bodies whereon they reſt, and are often by this means cemented to one another. Of ſuch a ſpecies is that univerſal cement which nature makes uſe of, as often as ſhe would erect in the ſea, or eſtabliſh therein a ſhell-work againſt the violent motion of the waves.

We have acquired but little knowledge of the induſtry of fiſhes. They are not ſufficiently within our reach. The greateſt part of them in-

 habit

habit gulphs that are inacceſſible to our reſearches. We do not preſume to think, that all their intelligence is confined ſolely to the devouring of each other. Their migrations are alſo as remarkable as thoſe of birds. They may have need of a kind of genius to enable them to chaſe their prey with ſucceſs, and elude the purſuit of their enemies. The *cuttle-fiſh* ſcatters about, at a proper ſeaſon, a black liquor, which troubles the water, and hides her from the ſight of ſuch fiſh as attempt to take away her life. Perhaps this liquor may be ſerviceable to her in ſeizing with the greater eaſe thoſe ſhe feeds upon. Other fiſhes can with abundance of art penetrate into very hard ſhells, and extract from thence the fleſhy ſubſtance contained in them. We are not yet acquainted with the uſe the *ſword-fiſh*, the *ſaw-fiſh*, and the *narval* or *unicorn-fiſh*, make of thoſe enormous inſtruments they wear at the end of their ſnouts; but they are undoubtedly able to handle them. Has not the *cramp-fiſh*, which ſo ſuddenly benumbs the hand that touches it, a very remarkable method of providing for its ſafety, and an excellent art to propoſe to the meditation of the natural philoſopher? The *flying-fiſh*, when purſued by others, darts out of the watry element to take refuge in the air, where it is for a time ſuſtained by its great fins.

It is well known that carp are capable of being tamed. and that they will haſten, like fowls, at a certain ſignal, to receive food from the hands of their provider.

It is probable that fiſhes are of all other animals endued with the longeſt lives. We have ſeen carp of an hundred and fifty years old. Fiſhes

transſpire

transſpire and harden but little: they have, properly ſpeaking, no bones. But they live in a ſtate of perpetual warfare. They all devour, or are devoured by others. Thoſe who attain to their age, muſt acquire an extenſive knowledge of things relating to the ſea. Such Neſtors as theſe may be able to procure us ſome good memoirs of the ſecret hiſtory of a people ſo little known.

25. We conjecture that the emigrations of birds depend principally on the winds. An exact naturaliſt at Malta has aſſured himſelf of this: that the ſame ſpecies always change their climate with particular winds. In April the *ſouth-weſt* wind brings into that iſland a ſpecies of *plovers*, and the *north-weſt*, *cardinals* and *quails*. Nearly at the ſame time, *falcons*, *buzzards* and other birds of *prey* come with the *north-weſt* wind, without ſtopping, and depart in October with the *ſouth* and *weſt*. In ſummer, the *eaſterly* wind conducts the ſnipes to Malta, and, towards the autumn, the *north* and *north-weſt* bring thither numerous ſquadrons of *woodcocks*. Theſe birds cannot fly, like the *quails*, before the wind; ſince the *north* wind, which might carry them into Barbary, obliges them to remain in the iſles. *Quails*, on the contrary, emigrate before the *wind* from one country to another. The *ſouth-eaſt* enables them to paſs, in the month of March, from Barbary into France. They return from France in September, and go to Malta by a *ſouth-eaſt*. The winds, therefore, are the ſignals employed by nature for reminding divers kinds of birds of the time of their departure. In obedience to this voice, they ſet out, and follow the direction it points out to them.

What a ſeries of intereſting circumſtances would not the conſtruction of their neſts alſo preſent us with! A chaffinch or gold-finch's neſt would take us up whole hours in contemplating it. We ſhould inquire where the gold-finch could furniſh itſelf with a cotton ſo fine, ſilky, and ſoft, as lines the inſide of its pretty neſt? After many reſearches, we ſhould find, that by covering the ſeeds of certain willows with a very fine cotton, nature has prepared for the gold-finch the down ſhe employs. We ſhould never be weary of conſidering that kind of embroidery with which the chaffinch ſo agreeably adorns the outſide of his neſt, and, on viewing it more narrowly, we ſhould perceive that it is owing to an infinity of little liverworts, artfully interwoven together, and applied with the utmoſt propriety over the whole ſurface of the neſt. The colour of theſe liverworts, which is moſt commonly that of the bark of the tree on which the neſt is ſituate, would indicate that the chaffinch ſeems to intend her neſt ſhould be confounded with the branch that bears it.

26. Shall we viſit the retreats of *rats*, *field mice*, *badgers*, *foxes*, *otters*, *bears*. We ſhould undertake thereby too tedious a journey. Let us limit ourſelves to the *rabbet* and *monkey*, as the moſt curious after thoſe of the beaver.

The *rabbet* and *hare*, which bear ſo near a reſemblance to each other both in their exterior and interior part, teach us not to truſt to appearances. They eaſily couple together, and produce nothing. They are therefore diſtinct ſpecies.

Moreover, the feeble hare contents herſelf with the lodging ſhe makes for herſelf on the ſurface of of the earth. The more induſtrious rabbet penetrates into the earth, and there procures an aſſured aſylum. The male and female live together in this peaceable retreat, fearleſs of the fox or bird of prey. Unknown to the reſt of the world, they ſpend their days in happineſs and tranquillity.

The hare might alſo dig the earth, but does not, neither does the domeſtic rabbet ſince he has no occaſion; his dwelling place being provided for him, he behaves as if he was ſenſible of it. The warren rabbet ſeems to know that he is unprovided, and procures for himſelf a lodging. But to perceive the relations thoſe retreats have to their preſervation, and to judge that they will ſhelter them from all the inconveniencies they labour under, is an operation of the ſoul that borders on *reflection*, if it be not reflection itſelf.

When the hare is ready to kindle, ſhe digs for herſelf a burrow. This is a winding trench, or one made in zig-zag. At the bottom of this trench ſhe works a great cavity, lining it with her own hairs. That is the ſoft bed ſhe prepares for her young. She does not quit them during ſeveral of the firſt days; and only goes out afterwards to procure nouriſhment. The father at that time knows nothing of his family: he does not dare to enter the burrow. When the mother goes into the fields, ſhe often takes even the precaution to ſtop up the entrance of the burrow with earth ſteeped in her urine. When they are grown ſomewhat larger, the leverets begin to brouſe the tender graſs. The father at that time acquires a knowledge of them, takes them up in his paws, licks their eyes, poliſhes their hair, and diſtributes his careſſes and cares equally amongſt them all.

Obſervations prove that paternity is greatly reſpected amongſt hares. The grandſire continues to be the chief of the whole numerous family, and ſeems to govern it like a patriarch.

27. The tricks of the *monkey* are known to every body. No one is ignorant with what facility ſhe is tamed, and taught to dance and ſhew poſtures on a ſtaff. Her ingenious proceedings on the tops of the Alps, where ſhe fixes her abode, in the midſt of ſnow and froſt, are not ſo generally known.

Towards the month of October, ſhe enters into winter quarters, and ſhuts herſelf up for the remainder of the ſeaſon. Her retreat is worthy of obſervation. On the brow of a mountain, the induſtrious monkey eſtabliſhes her dwelling. It is a great gallery dug under-ground, and made like a Y. Theſe two branches, which have each of them an opening, terminate at a *corner*. Such is the apartment of the monkey. One of the branches deſcends below the apartment, according to the ſloping of the mountain; it is a kind of aqueduct that receives and carries off the excrements and filth. The other branch, which riſes above the habitation, ſerves for an avenue and place to go out at. The apartment is the only part of the gallery which is horizontal. It is lined with a thick layer of moſs and hay. It is certain that monkeys are ſociable animals, and that they work in common on their lodging. They amaſs during the ſummer ample ſupplies of moſs and hay. Some mow the graſs, others gather it, and by by turns they ſupply the office of a cart to convey it to the ſtorehouſe. One of the monkeys lies on his back, opens his paws to ſerve inſtead of *racks*, ſuffers himſelf to be loaded with hay, and drawn by the reſt, who hold him by the tail, and are careful to prevent the carriage being overturned on the road. Their feet are armed with claws, which enable them with great eaſe to dig into the earth. As ſoon as they have made a hollow place in it, they throw behind them the dirt they extract from the mine. They paſs the greateſt part of their life in their habitation; they retire into it during the rain, or on the approach of a ſtorm, or at the ſight of ſome imminent danger. They ſeldom quit it except in fine weather, and go but a little way from it. Whilſt ſome are ſporting on the turf, others are buſy in cutting it, and a third party are acting as ſcouts on the eminences, to give notice to the foragers, by a whiſtle, of the enemy's approach.

During the winter, monkeys eat nothing. The cold benumbs them, ſuſpends or greatly diminiſhes perſpiration, and other excretions. The fat with which their belly is well provided paſſes into the blood, and reſtores it. We might affirm that they foreſee their lethargy, and are apprized that they ſhall then have no need of nouriſhment; for they do not think of hoarding up proviſions, as they do materials for furniſhing their lodging.

28. We have greatly admired the ingenious and almoſt intelligent mechaniſm, by which divers caterpillars roll up the leaves of trees. You ſee theſe aſh-leaves that are rolled up like a coffin. They are inhabited by a little caterpillar, that has

formed for itſelf therein a cone of pure ſilk, nearly reſembling a grain of corn. We cannot examine this cone without opening the coffin. Let us do it with caution. The cone is lodged in the centre. You perceive little gutters on the exterior part of it. Obſerve particularly in what manner this little cone is ſuſpended in the middle of the coffin, by the help of a thread, one of whoſe extremities is fixed to the top of the cone, and the other to its baſe, or the flat part of the leaf. Look narrowly at the place where the thread joins to the flat part of the leaf: you will perceive a ſmall piece in it exactly circular, bored in the thick part of the leaf, and that ſeems to conceal ſome ſecret deſign. This you will find in many coffins; but it often happens that you will ſee in that place a little round hole, well turned, that appears to have been made by a *gimblet*. The circular piece is the work of the caterpillar: it has ſkilfully gnawn that part of the leaf; and has cut a little piece of it in a circular form, which it has been very careful to leave in its place. You ſeem to diſcern the end of this labour. It is contrived for a private paſſage for the caterpillar to go out at, at the ſame time that it prevents the entrance of any miſchievous inſects. Our induſtrious caterpillar then makes a little door into its cell. This door is not to be opened till after the laſt metamorphoſis. The winding parts of it being interwoven with the leaf, it remains as it were ſubſervient to it. In iſſuing from the cone, the caterpillar deſcends by the whole length of the thread, which holds it ſuſpended; it follows the direction of it, arrives at the door, and burſts it open by puſhing its head againſt it. Theſe coffins, which you ſee pierced through,

through, have been abandoned by the caterpillars.

29. Our grain is liable to be eaten by a very ſmall inſect, that lodges within it, and is there metamorphoſed. The covering of corn is a kind of very cloſe box, which the caterpillar lines with ſilk. But the caterpillar is provided with no inſtrument to pierce through this box, and would remain priſoner therein, if the inſect were not inſtructed how to prepare a paſſage from it. It proceeds in the ſame manner as the roller of the aſh; it cuts with its teeth a little round place in the covering of the grain, which it is very careful not to diſengage entirely from it. The butterfly need only preſs againſt this part, in order to obtain its liberty.

In the center of the *capper* thiſtle there is a large oblong cavity, which is commonly inhabited by a ſmall caterpillar, that makes a ſort of cone therein, where ſhe transforms herſelf. The rind of the thiſtle is much harder than that of our corn. It would be impoſſible for the butterfly to force a paſſage through it. It would have occaſion for very ſtrong teeth for that purpoſe, and is furniſhed with no analogous inſtruments. The caterpillar, which ſeems ſenſible of this, makes a ſkilful proviſion for the neceſſities of the butterfly. It pierces in different parts the walls of its lodge, and makes a ſmall round hole in it, oppoſite the extreme part of the cone which the butterfly is to go out at. But, were this hole to remain open, the chryſalis would be too much expoſed. The caterpillar contrives a very ſimple expedient for ſtopping up the aperture. The whole exterior part of the head of the thiſtle is covered with the ſeeds of the plant. The caterpillar brings ſome of theſe little bodies to the outſide of the hole.

In treating of the proceedings of *aquatic* moths, we have remarked that they transform themſelves in their caſe. There muſt be a continual freſh ſupply of water in this incloſure: yet, no voracious inſect ſhould be allowed acceſs to it. Inſtead of placing a full made door at the entrance of its lodge, the moth puts a grated one there, which anſwers every end. Let us not attribute our method of reaſoning to this moth. Does ſhe know that voracious inſects have a deſign againſt her life? Is ſhe ſenſible that ſhe will put on a form under which ſhe will not be able to fly? No; ſhe is ignorant of all this; nor does it concern her to know it. She has been taught to ſpread threads that are capable of growth; ſhe does ſpread them, in ſo doing, ſhe provides by a machine againſt the inconveniencies which ſhe neither knows or can know. Judge on the ſame principle of other facts of this kind. It is always the AUTHOR of the inſect who alone is to be eſteemed wonderful.

30. I need not then endeavour, from the end which we diſcover in the work of an induſtrious animal, to find a reaſon for this work. I would not ſay, *The ſpider ſpreads a net to catch the flies*; but that *the ſpider catches the flies becauſe ſhe ſpreads a net*, &c. and ſhe forms a net, becauſe ſhe has *occaſion to ſpin*. The end is not leſs certain, or leſs evident; only, it is not the animal that has propoſed it, but the AUTHOR of the animal.

animal. What loſs would natural theology ſuſtain by this method of reaſoning? Would it not, on the contrary, acquire a greater degree of exactneſs? Let us reaſon then on the operations of animals as we do on their ſtructure. The ſame WISDOM, which has conſtructed and arranged with ſo much art their various organs, and has cauſed them to concur to one determinate end, has likewiſe cauſed thoſe numerous operations, which are the natural effects of the œconomy of the animal, to contribute to one end. He is directed towards his end by an inviſible HAND; he executes with preciſion, from the very beginning, the works which we admire; he ſeems to act as if he was capable of reaſoning, to turn about with propriety, and to change his method as there is occaſion, and in all this only obeys thoſe ſecret ſprings by which he is actuated; he is only a blind inſtrument that cannot judge of his own action, but is excited to it by that ADORABLE MIND which has traced out to every inſect his little circle, as he has marked out to each planet its proper orbit. When therefore I ſee an inſect working on the conſtruction of a net, a cone, or a chryſalis, I am ſeized with reſpect, becauſe I am beholding a ſight where the SUPREME ARTIST is concealed behind the ſcene.

31. Many ſpecies of ſolitary bees content themſelves with penetrating into the earth; ſcoop out cylindrical cavities therein, and poliſh the walls. They depoſit an egg there and amaſs a ſufficient quantity of nouriſhment.

There is another ſpecies of theſe worms that pierce the earth, whoſe induſtry is much more remarkable.

remarkable. They do not content themselves, like the others, with an entire naked cavity. On visiting the inside of the lodge, immediately after its construction, we are agreeably surprized to see it hung quite round with tapestry of the most beautiful crimson sattin, affixed to the sides as our tapestry is to the walls of our apartments, but with much more propriety. The bee does not only line in this manner the whole inside of her dwelling; but also spreads the same kind of tapestry round the entrance to the distance of two or three lines. We have observed many caterpillars that line the inside of their cone or inclosure with silk: our bee is the only insect at present known, which, properly speaking, hangs her nest with tapestry, as we do our apartments. It is therefore with good reason that this industrious animal has received the name of the tapestry-bee.

You seem at a loss to know from whence she procures the rich tapestry. Look at the flowers of this wild-poppy, which are newly blown: observe that they are sloped here and there. Compare them with the tapestry whose tissue you are desirous of knowing, you can find no difference between them: this tapestry is no other than the fragments of the flowers of the wild poppy; and that is the secret origin of those slopings you remark on the poppies that border upon the nest. Your curiosity is not yet satisfied; you are desirous of observing a little the labour of our skilful worker in tapestry.

The hole, which she digs perpendicularly into the earth, is about three inches in depth. It is exactly cylindrical, as far as to seven or eight lines

lines of the bottom. There it begins to open wider, which it does more and more. When the bee has made an end of giving it the suitable proportions, ſhe proceeds to line it with the tapeſtry.

With this view, ſhe applies herſelf to cutting, with abundance of art, pieces of petals † of an oval form from the flowers of the wild-poppy, which ſhe ſeizes with her legs, and conveys into her hole, Theſe little ſcraps of tapeſtry, when tranſported thither, are very much crumbled; but the *tapeſtry-bee* knows how to ſpread them out, diſplay them, and affix them to the walls with aſtoniſhing art.

She applies at leaſt two layers of the petals. She ſpreads two tapeſtries on each other. The reaſon of her furniſhing herſelf with it from the flowers of the wild-poppy rather than from thoſe of many other plants, is, becauſe in them are united to a higher degree all thoſe qualities which are requiſite for the uſe to which the bee deſigns to put them.

When the pieces which the bee has cut and tranſported are found to be too large for the place they are intended to occupy, ſhe cuts off the ſuperfluous parts of them, and conveys the *ſhreds* out of the apartment.

After hanging the tapeſtry, the bee fills the neſt with *paſte*, to the height of ſeven or eight lines. This is all that is neceſſary for the nouriſhment of the worm. The tapeſtry is deſigned to prevent the mixture of particles of earth with the paſte.

† This is the name given by botaniſts to the leaves of flowers.

You

You expect undoubtedly that the prudent bee should not fail to close up effectually the aperture of the nest, in order to hinder the access of those insects into it that are fond of the paste: this she takes proper care to do: and it is utterly impossible for you to discover, from the surface of the ground, the spot where the nest was, whose construction you have just been contemplating, such is the skill employed by the bee in closing it. This little white pebble was at the edge of the hole, or very near it; it has not changed its place, and indicates to us the part beneath which the nest is we are searching for. It seems then as if we should have nothing more to do than to raise up a light layer of earth, in order to expose to view the entrance of the hole which has been so well closed. Nothing can be easier or less doubtful. How great is your surprise! you have already taken up two or three inches of the earth in depth, and you cannot find the least appearance either of the hole or the tapestry. What can this mean? What is become of the nest that was so skilfully constructed, so properly lined, and was upwards of three inches deep? A few hours since, you admired the ingenious contrivance of it, and now the whole has disappeared, so that you cannot discover the least trace of it. What mystery then is this? It is effected as follows:

When the bee has done laying, and amassed her quantity of paste, she takes down the tapestry, folds it over the paste, which she wraps together in it pretty nearly as we fold on itself a coffin of paper that is half full. The egg and paste are by this means inclosed within a little bag of flowers. The bee has then nothing farther to do, but to fill up with earth all the void space that is above the

the bag; and this ſhe performs with ſuch wonderful activity and exactneſs, as utterly to conceal the place where the neſt was.

If a hare does not poſſeſs, like the rabbet, the art of digging for himſelf a burrow, he does not however want a ſufficient degree of ſagacity to enable him to ſecure himſelf, and eſcape from his enemies. He can chooſe for himſelf a form, and conceal himſelf betwixt clods of earth that reſemble the colour of his hair. In winter, he takes up his lodging to the ſouth, and in ſummer time to the north; when ſtarted by the dogs, he purſues the ſame track for ſome time, goes the ſame way back again, darts aſide, throws himſelf into a buſh, and there ſquats down. The pack follow the path, paſs before the hare, and loſe ſcent of him.

The crafty animal ſees them paſs by and run far from him, he iſſues from his retreat, confounds his courſe, and puts the hounds to a loſs. He varies his ſhifts continually, and always conducts them as his circumſtances require. Sometimes at the cry of the hounds, he quits his form, ſpeeds away to the diſtance of a quarter of a league, caſts himſelf into a pond, and lies hid among the ruſhes. At others he mingles with a flock of ſheep, and will not abandon them. One time he conceals himſelf under ground: at another leaps under a ruinous wall, crouches among the ivy, and lets the dogs paſs him. Oftentimes he runs along one ſide of a hedge, whilſt the dogs go on the other. Sometimes by ſeveral efforts he ſwims acroſs a river. Laſtly, at others he obliges another hare to quit the form, in order to ſupply his place, &c.

The

The ſtag, which by the elegance and lightneſs of his make, by thoſe living *branches* with which his head is rather adorned than armed, his ſize, ſtrength, and noble air is one of the grand ornaments of the foreſt, is endued with more ſubtlety than even the hare, and finds more exerciſe for the ſagacity of the huntſman.

When purſued by the hounds, he paſſes and repaſſes ſeveral times on his track; eludes their purſuit by aſſorting himſelf with other beaſts, darts forward, and immediately flees to a diſtance, ſtarts aſide, and ſteals away, and lies proſtrate on his belly. The land betraying him every where, he betakes himſelf to the water. The hind that nouriſhes her young, preſents herſelf to the dogs, in order to facilitate the eſcape of her young, ſhe runs away with ſwiftneſs, and afterwards returns to it.

32. The fox, celebrated for his ſubtility, is no leſs circumſpect than ſkillful, no leſs vigilant than crafty, he weighs cautiouſly the leaſt of his meaſures, ſtudies circumſtances, watches inceſſantly, and has always ſome contrivance in reſerve to aſſiſt him upon an exigency. His genius is ſo fruitful in reſources, multiplies almoſt to infinity his ſhifts and ſtratagems.

Though extremely fleet in running, he does not truſt to his natural ſwiftneſs: he judges that that alone would not be ſufficient for his preſervation. He works for himſelf a timely aſylum under ground: where he takes refuge in caſe of neceſſity, and lodges, and brings up his family.

He eſtabliſhes his dwelling place on the border of woods, and in the neighbourhood of farm-

houſes

houſes. He liſtens afar off with an attentive ear to the cackling of poultry, directs his ſteps accordingly, arrives by ſeveral winding ways, ſquats himſelf down, paſſes along on his belly, lies in ambuſcade, and rarely fails in his attempt.

If he is ſo happy as to penetrate into the incloſure, he employs to good purpoſe every moment of his time, and ſlaughters the whole ſtock. He immediately retreats, carries away with him one of the prey, conceals it, returns in ſearch of another, hides that like the former, and does not ceaſe from plundering, till he perceives he has been diſcovered.

He is amazingly ſkilful in hunting young leverets, ſurprizing the hares when lying down; in diſcovering the neſts of partridges, or quails, and ſeizing the mother on her eggs.

Equally bold as crafty, he has even the courage to attack bees: he attempts to get their honey, which he is very fond of. Theſe warlike inſects preſently aſſail him on all ſides, and in a few moments he is entirely covered with them. He retires ſome paces, rolls himſelf on the ground, cruſhes them by that means, returns to the charge, and at length obliges this little laborious people to abandon to him the fruits of their long labours.

I ſhall add but one more inſtance: if the fox diſcovers that his young have been diſturbed during his abſence, he tranſports them one after another to a new place of retreat.

CONCLUSION.

HERE I ſet bounds to my deſign. I have preſented my readers with a variety of facts of an intereſting nature, ſufficient to enable them to form an idea of thoſe pleaſures which reſult from the contemplation of nature. But this contemplation would prove fruitleſs, did it not lead us to aſpire inceſſantly after this adorable BEING, by endeavouring to acquire a knowledge of him, from that immenſe chain of various productions wherein his power and wiſdom are diſplayed with ſuch diſtinguiſhed luſtre. He does not impart to us the knowledge of himſelf immediately; that is not the plan he has choſen; but he has commanded the heavens and the earth to proclaim his exiſtence, to make him known to us. He has endued us with faculties ſuſceptible of this divine language, and has raiſed up men who explore their beauties, and become their interpreters. Impriſoned for a while in a ſmall obſcure planet, we only enjoy ſuch a portion of light as is ſuitable to our preſent condition: let us wiſely improve each glimmering ray reflected upon us, nor loſe the

ſmalleſt

ſmalleſt ſpark: let us continually advance in this effulgent light! A time will come, when we ſhall draw all light from the Eternal Source of Light and inſtead of contemplating the Divine Architect in the works of his hands, ſhall contemplate the workmanſhip in the OMNIPOTENT AUTHOR thereof. "We now ſee things as through a "glaſs darkly; but we ſhall then ſee face to face."

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